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PUGET SOUND VESSEL TRAFFIC SERVICE WATCHSTANDER ANALYSIS.(U)

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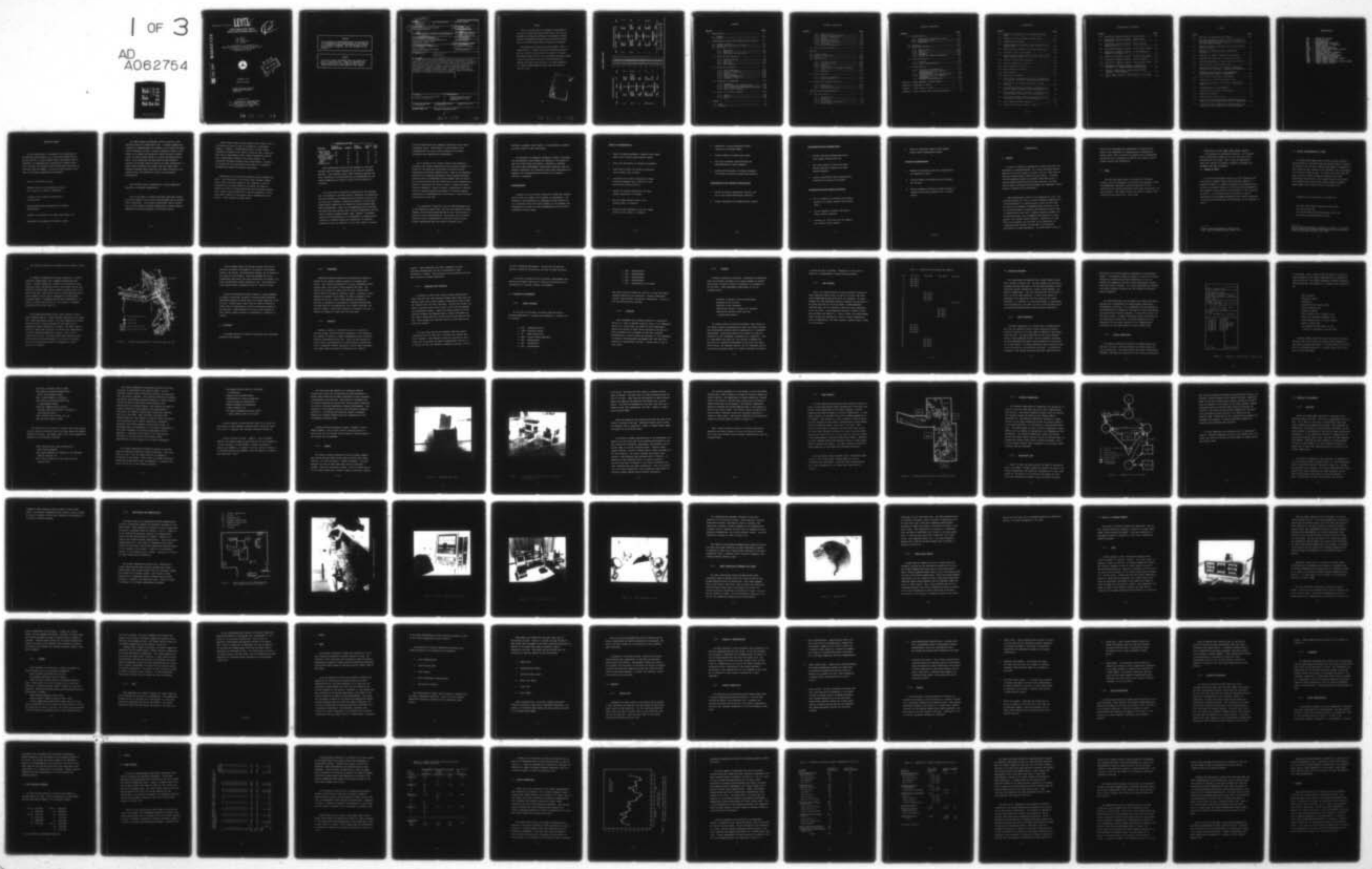

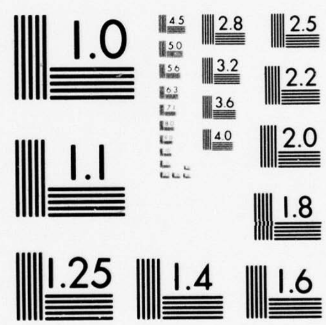


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REPORT NO. CG-D-82-78

# PUGET SOUND VESSEL TRAFFIC SERVICE WATCHSTANDER ANALYSIS

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U.S. Department of Transportation
Research and Special Programs Administration
Transportation Systems Center
Cambridge MA 02142



NOVEMBER 1978

INTERIM REPORT



Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
Office of Research and Development
Washington DC 20590

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**Technical Report Documentation Page**

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| CG-D-82-78 | | |

| | |
|---|---|
| 4. Title and Subtitle<br>PUGET SOUND VESSEL TRAFFIC SERVICE WATCHSTANDER ANALYSIS. | 5. Report Date<br>November 1978 |
| | 6. Performing Organization Code |
| 7. Author(s)<br>D.B. Devoe, J.W. Royal, C.N. Abernethy and K.J. Kearns | 8. Performing Organization Report No.<br>DOT-TSC-USCG-78-13 |
| 9. Performing Organization Name and Address<br>U.S. Department of Transportation<br>Research and Special Programs Administration<br>Transportation Systems Center<br>Cambridge MA 02142 | 10. Work Unit No. (TRAIS)<br>CG-913/R9002 |
| | 11. Contract or Grant No. |
| 12. Sponsoring Agency Name and Address<br>U.S. Department of Transportation<br>U.S. Coast Guard<br>Office of Research and Development<br>Washington DC 20590 | 13. Type of Report and Period Covered<br>Interim Report, April 1977-May 1978, |
| | 14. Sponsoring Agency Code |

6 11 14 10 9

15. Supplementary Notes

12 249p.


16. Abstract

A team of human factors specialists analyzed the performance of watchstanders in the U.S. Coast Guard's Puget Sound Vessel Traffic Center at Seattle WA. Data collected included copies of the center's forms and logs, records and tapes of watchstander activities for a total of 12 hours of observation, records of 6-in-depth interviews with center personnel, stress questionnaires administered to 14 watchstanders, comments on center services by 6 Puget Sound pilots, and photographs of equipment and workspace layout. Analysis of the data yielded a breakdown of watchstander time utilization, a summary of communications loading, and twenty-three suggestions for improving operations.


| 17. Key Words | 18. Distribution Statement |
|---|---|
| Vessel Traffic Service, Watchstander Performance, Human Factors | DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161 |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 212 | |

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized



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## PREFACE

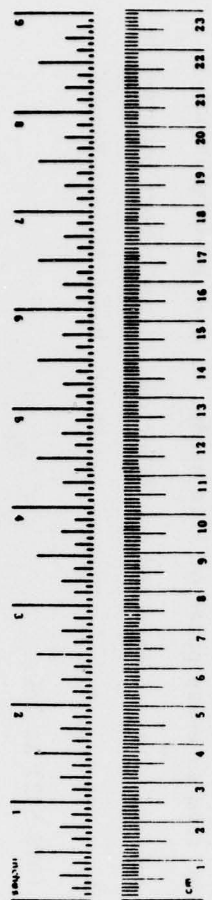
This is an interim report on the analysis of watchstander activities at the Puget Sound Vessel Traffic Service. The study was performed by the Human Factors Branch of the Department of Transportation's Transportation Systems Center (TSC) under the sponsorship of the US Coast Guard's Office of Research and Development.

The authors wish to express their sincere thanks to LCDR C. T. Johnson and LT P. R. Corpuz of the Office of Research and Development and to CAPT N. G. Nelson and all the personnel of the Puget Sound Vessel Traffic Service for the encouragement and support provided by them in every phase of this study. We also gratefully acknowledge the guidance and contributions to the report provided by H. P. Bishop, Program Manager and Chief, Human Factors Branch (DTS-532) at TSC.

# METRIC CONVERSION FACTORS

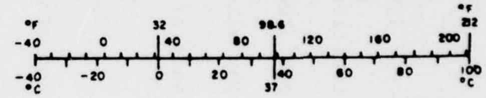
## Approximate Conversions to Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | 2.5 | centimeters | cm |
| ft | feet | 30 | centimeters | cm |
| yd | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 6.5 | square centimeters | $cm^2$ |
| $ft^2$ | square feet | 0.09 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.8 | square meters | $m^2$ |
| $mi^2$ | square miles | 2.6 | square kilometers | $km^2$ |
| | acres | 0.4 | hectares | ha |
| | | **MASS (weight)** | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |
| | | **VOLUME** | | |
| tsp | teaspoons | 5 | milliliters | ml |
| Tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| $ft^3$ | cubic feet | 0.03 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.76 | cubic meters | $m^3$ |
| | | **TEMPERATURE (exact)** | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |



## Approximate Conversions from Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.04 | inches | in |
| cm | centimeters | 0.4 | inches | in |
| m | meters | 3.3 | feet | ft |
| m | meters | 1.1 | yards | yd |
| km | kilometers | 0.6 | miles | mi |
| | | **AREA** | | |
| $cm^2$ | square centimeters | 0.16 | square inches | $in^2$ |
| $m^2$ | square meters | 1.2 | square yards | $yd^2$ |
| $km^2$ | square kilometers | 0.4 | square miles | $mi^2$ |
| ha | hectares (10,000 $m^2$) | 2.5 | acres | |
| | | **MASS (weight)** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.2 | pounds | lb |
| t | tonnes (1000 kg) | 1.1 | short tons | |
| | | **VOLUME** | | |
| ml | milliliters | 0.03 | fluid ounces | fl oz |
| l | liters | 2.1 | pints | pt |
| l | liters | 1.06 | quarts | qt |
| l | liters | 0.26 | gallons | gal |
| $m^3$ | cubic meters | 35 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.3 | cubic yards | $yd^3$ |
| | | **TEMPERATURE (exact)** | | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |



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ILLUSTRATIONS (CONTINUED)

TABLES

## ABBREVIATIONS

| | | |
|---|---|---|
| COTP | - | Captain of the Port |
| CRT | - | Cathode Ray Tube |
| DR | - | Dead Reckoning |
| ETA | - | Estimated Time of Arrival |
| ETD | - | Estimated Time of Departure |
| LOA | - | Length Overall |
| PPI | - | Plan Position Indicator |
| PSVTS | - | Puget Sound Vessel Traffic Service |
| SOA | - | Speed of Advance |
| SOP | - | Standard Operating Procedure |
| STC | - | Sensitivity Time Control |
| TSC | - | Transportation Systems Center |
| TSS | - | Traffic Separation Scheme |
| VMRS | - | Vessel Movement Reporting System |
| VTC | - | Vessel Traffic Center |
| VTMS | - | Vessel Traffic Management System (Canada) |
| VTS | - | Vessel Traffic Service |

## EXECUTIVE SUMMARY

For the second study in a program for the evaluation of watchstander productivity in U.S. Coast Guard Vessel Traffic Services (VTS's), a team of human factors specialists from the Department of Transportation's Transportation Systems Center (TSC) collected and analyzed data on watchstander activities at the Puget Sound VTS (PSVTS). During the period January 24-27, 1978, the following information was obtained:

Copies of VTS forms and logs,

detailed records of watchstander activities for a total of 12 hours of observation,

records of six in-depth interviews with VTS personnel,

stress questionnaires administered to fourteen watchstanders,

comments on the PSVTS by six Puget Sound pilots, and

photographs of equipment and workspace layout.

The PSVTS divides watchstander duties by function, each function serving the entire PSVTS area. A Primary Communicator receives all communications from vessels in the system and issues traffic advisories to them. A Plotter prepares a model of each vessel in the system and maintains a current picture of system traffic by moving vessel models on a large, map-based plotting table. Vessel positions are determined by dead reckoning augmented by periodic position reports and radar observations. A Radar Operator monitors the returns from four radar sites, compares indicated vessel positions with model locations on the plotting table, and advises the Plotter of any observed discrepancies.

This "Traffic Team" is supervised by a Watch Supervisor, assisted by an External Communicator.

Duty at the PSVTS is divided into three eight-hour watches, each watch staffed by four enlisted watchstanders and one officer (Watch Supervisor). The enlisted watchstanders rotate through the four duty positions (Primary Communicator, Plotter, External Communicator and Radar Operator) for two-hour periods.

PSVTS records show an average annual (1977) traffic load of 540 vessels per day: 95 tugs, 22 freighters, 15 government vessels, 4 tankers, 3 miscellaneous craft, and 400 ferries, including 44 vessels in the Strait of Juan de Fuca. During the four days of observations, daily traffic averaged 543 vessels with a distribution similar to the annual figures. No significant incidents occurred during observations. Therefore, we conclude that our observations were based on a reasonably representative sample of "routine" operations.

Activities at the various duty positions were tabulated and timed. The activities of the "Traffic Team" (Primary Communicator, Plotter and Radar Operator) were combined to show the percentage of team time devoted to each major VTS function. Adding the time of the Watch Supervisor and the External Communicator ("Watch Team") yielded even a smaller proportion of total watch effort devoted to the primary job of communicating with vessels. These figures are shown below:

| Function | Primary Communicator | Plotter | Radar Operator | Traffic Team | Watch Team |
|---|---|---|---|---|---|
| | Percentage of Time | | | | |
| Communicating | | | | | |
| With Vessels | 40 | 0 | 0 | 13 | 8 |
| With Others | 5 | 7 | 2 | 5 | 7 |
| Monitoring Traffic | 43 | 18 | 62 | 41 | 30 |
| Plotting Traffic | | | | | |
| Plotting Table | 2 | 40 | 2 | 15 | 9 |
| Cards | 8 | 2 | 0 | 3 | 2 |
| Radar | 0 | 0 | 19 | 6 | 4 |
| Miscellaneous | 2 | 33 | 15 | 17 | 40 |

These observations agree with the comments of the watchstanders that the Primary Communicator has the most strenuous workload. Since routine traffic loads frequently approach the level considered by the watchstanders as uncomfortable for the Primary Communicator to handle, relief for this position is indicated.

Some relief may be obtained by consolidation and rearrangement of equipment at the work station, correction of illumination and noise problems, and simplification of advisory contents, but the only way to achieve a significant reduction of the Primary Communicator's workload is to divide the traffic handled among other watchstanders. This can be accomplished only by dividing the PSVTS area into sectors, with a Primary Communicator for each sector handling a lighter traffic load. However, a necessary condition for sectorization is an improvement in communications capability to prevent overlap and interference of messages, requiring in turn the addition of one or more channels reserved

for VTS communications and, perhaps, relocation of some radio transmitter sites. Sectorization is thus treated in our recommendations as a goal in the evolution of the PSVTS, contingent upon communications improvements.

The 13 percent of the "Traffic Team's" time devoted to delivering the product (communicating with vessels) reduces to 8 percent of the Watch Team's time when we add the time for supervision and external communications. Some of the supporting activities are obviously necessary to permit product delivery. However, there is considerable "miscellaneous" time (40 percent of the total time for the full Watch Team), and the combined time devoted to monitoring the traffic (nearly a third) very likely contains redundancy. Study is required, particularly a detailed review of standard operating procedures, to determine whether reallocation of responsibilities could result in a more efficient distribution of team time.

It is important to note here that the "miscellaneous" time is not necessarily wasted time. The team must respond to system demands, and even when system demands are few, the team must be prepared to meet maximum demands. The present data on routine operations must be supplemented by additional data on watch-stander requirements when the system is stressed (as by

accidents, incidents, heavy traffic, or bad weather) to justify any major changes in duty allocations.

As operations are presently conducted at PSVTS, we estimate that sectorization could require the addition of one person to each Watch Team rather than permit a reduction in staffing. Long-range system developments (particularly improved radar and computer assistance) will eventually permit more consolidation of equipment into standardized work stations and a possible reduction in manpower.

## Recommendations

Analysis of all of the data collected at PSVTS has revealed several areas that appear to be amenable to improvements. The feasibility and desirability of implementing these changes can not be determined from this study; however, we do recommend that consideration be given to these recommendations and that their feasibility be given study.

Immediate Recommendations

a. Adopt as standard procedure a complete radar update before each 15-minute dead-reckoning update.

b. Review and standardize all operating procedures.

c. Study ways to reduce the number of advisories and to shorten their contents.

d. Consolidate the Primary Communicator's communications equipment into a smaller and more conveniently located position.

e. Elevate the Primary Communicator and Radar Operator positions, if feasible.

f. Move the Radar Operator closer to the plotting table, if feasible.

g. Rearrange radar equipment to make the scopes visible to the Plotter, if feasible.

h. Substitute a tinted transparent plastic curtain for the window drapes.

i. Continue efforts to reduce glare spots.

j. Seek ways to improve light-shielding and sound-shielding of radar equipment.

k. Improve sound-shielding of teletype equipment and relocate at External Communicator position.

Recommendations with Improved Communications

l. Divide the Primary Communicator function into two or more Sector Watchstander Positions.

m. Further consolidate the communications console.

Recommendations with Improved Radar

n. Provide each Sector Watchstander with a radar display covering his area.

o. Plot radar traffic at the Sector Watchstander positions; eliminate the Radar Operator position.

p. Design a consolidated radar-communications console for the Sector Watchstander.

Recommendations with Computer Assistance

q. Use the computer for tracking and plotting; eliminate the Plotter position and plotting table.

r. Use the computer to predict and display future traffic situations.

s. Integrate the radar data into the computer for automatic radar tracking.

t. Design an integrated computer-radar-communications Sector Watchstander console.

## Personnel Recommendations

u. Redefine VTS duties to give more responsibility and authority to CPO's.

v. Continue efforts to develop selection criteria for VTS duty.

w. Modify assignment practices to permit overlap of incoming and outgoing personnel for a training period.

# 1. INTRODUCTION

## 1.1 Purpose

In order to reduce the probability of vessel collisions and groundings in crowded waterways, and to keep individual vessels apprised of the total traffic situation, the U.S. Coast Guard is operating several Vessel Traffic Services (VTS's). To profit from the experience gained in operating these VTS's, both to improve present services and plan future services, the Coast Guard's Office of Research and Development has undertaken a broad program of analysis of VTS operations.

Human performance is basic to the operation of a VTS. The principal product of a VTS is a traffic advisory communicated by a VTS watchstander to a vessel master or pilot via VHF radio. The value of the advisory is dependent upon the skills of the various watchstanders in acquiring and monitoring traffic data, in integrating the data into a coherent picture of present and anticipated traffic, and in composing and delivering a clear, concise, and accurate traffic advisory. Therefore, the Coast Guard has recognized that any model of VTS operations and productivity must include the influence of watchstander performance on system performance. The Coast Guard's Office of

Research and Development has commissioned the Human Factors Branch of the Department of Transportation's Transportation Systems Center (TSC) to obtain and analyze data on watchstander performance and to integrate the results into models of watchstander activity and productivity.

## 1.2 Scope

For its first year's work on this study of VTS watchstanders, TSC has undertaken the collection and analysis of data on Watchstander activities in routine operations in four operating VTS's: Houston-Galveston, Puget Sound, New Orleans, and San Francisco. This report presents the initial results of the analysis of the second VTS -- Puget Sound.

## 2. DESCRIPTION OF PUGET SOUND VESSEL TRAFFIC SERVICE

A VTS operation is continually changing. The following section describes the PSVTS as it was at the time of data collection for this study. Even at time of publication, significant changes in staffing, schedules, procedures and equipment have been introduced.

### 2.1 Purpose of VTS's

The Ports and Waterways Safety Act of 1972 authorizes the Coast Guard to operate vessel traffic services (VTS's) in designated areas to "...prevent collisions and groundings and to protect the navigable waters of the VTS area from environmental harm resulting from collisions and groundings."[1] VTC's meet this objective "...by providing pilots and masters of vessels information on the teletype concerning vessel traffic conditions and navigational hazards that would otherwise not be available to them".[2]

---

[1]Code of Federal Regulations, 33CFR161.101.
[2]Puget Sound VTS Traffic Center Manual, #1.1.2

## 2.2 General Characteristics of PSVTS

The Puget Sound Vessel Traffic Service (PSVTS) provides a 24-hour service in the Puget Sound and adjacent waters, including the Strait of Juan de Fuca.[3] Vessel participation is mandatory in Puget Sound and some adjacent waters (33CFR161), but is voluntary in the Strait of Juan de Fuca. The PSVTS area covers about 800 miles of waters used for commercial purposes, with radar surveillance over 80 miles. The northern portion of the PSVTS area interfaces with the Canadian Vessel Traffic Management System (VTMS) with a control center in Vancouver, BC.

Included in the area served by the PSVTS are:

The Puget Sound Traffic Separation Scheme (TSS)
the Juan de Fuca TSS,
four VHF-FM Radio Transmitter/Receiver Sites, and
four Radar Transmitter/Receiver Sites.

---

[3]Unless otherwise specified, information in Section 2 is derived from the PSVTS Traffic Center Manual and additional unpublished reference materials supplied by the PSVTS.

The principal features of the PSVTS area are shown in Figure 2-1.

The PSVTS is comprised of two major components, a Traffic Separation Scheme (TSS), and a communications/surveillance system. The TSS consists of a network of precautionary areas, separation zones, and one-way traffic lanes within the VTS area designed to safely route traffic between the major ports in the Puget Sound area. The traffic lanes are 1,000 yards wide with a minimum depth of 60 ft. and are separated by 500-yard-wide separation zones. A voluntary TSS has been established in the strait of Juan de Fuca by the U.S. and Canada as a "seaward extension" of the Puget Sound VTS.

The communications/surveillance system includes a VHF-FM radio-telephone system, a Vessel Movement Reporting System (VMRS) and a radar surveillance system. The radio communication system permits the VTS to obtain information from vessels and to disseminate traffic information to vessels. The VMRS requires vessels to report their position via VHF-FM radio communications at several specified geographical points as well as when requested by the VTS. The radar surveillance system provides a visual picture of traffic movement in the areas of coverage, which aids in maintaining accurate information on traffic location and movement.

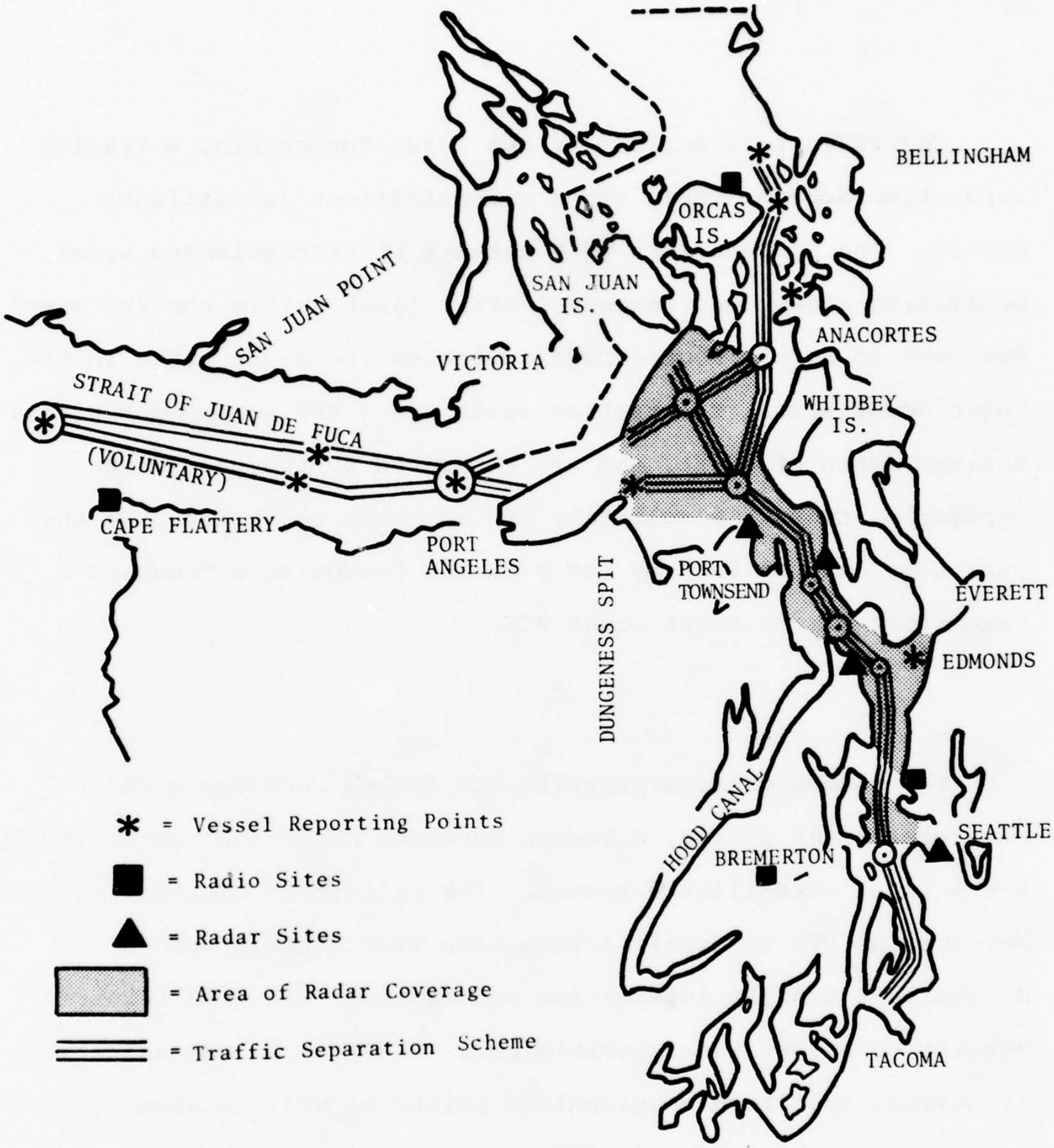


FIGURE 2-1. GENERAL CHARACTERISTICS OF THE PUGET SOUND VTS AREA

The VTS handles about 540 transits per day, some 16% of which are tug boats, 4% freighters, 1% tankers, 2% government vessels, 69% ferries, 1% miscellaneous vessels, and 7% traffic in the Strait of Juan de Fuca. Plans are underway for an oil transhipment port which, when fully operational, can result in at least one additional tanker movement per day. The presence of large tankers poses a continual threat of a major oil spill.

Ferry and recreational vessels comprise a large proportion of traffic in the area, of which 18 ferries linking waterside communities account for about 69% of the vessels operating in the VTS area. Ferries whose routes cross the Traffic Separation Scheme (TSS) are monitored by the VTS; recreational traffic is not monitored. Radio reports to the VTS are not required of ferry vessels unless the route is unscheduled or visibility is reduced.

## 2.3 Functions

The PSVTS provides its services through two major functions: monitoring and advising.

### 2.3.1 Monitoring

Monitoring involves creating and maintaining as accurate a picture of the current traffic situation as available data permit. This picture is presented on a large illuminated traffic display table, also called a dead-reckoning (DR) plot. The surface of the table is a map of the VTS area on which small vessel models are placed to represent traffic. Whenever a vessel reports its position via the VMRS, its model is placed at that position on the map. Every fifteen minutes each vessel's position is advanced to a new position calculated through dead-reckoning based on the destination, last reported position, and speed of advance. Where radar coverage is available, the plot is checked and adjusted to agree with the radar data.

### 2.3.2 Advising

Whenever a vessel is contacted by radio it is given an advisory on what traffic and other situations it will encounter. The advisory is based on a mental extrapolation from the traffic situation represented by the plot. Advice is also provided on marine events, concentrations of fishing vessels, problems with aids to navigation, weather conditions, and any other situations that might affect the safety or convenience of a vessel's

transit. Under conditions of traffic congestion or other hazardous circumstances, the VTS is authorized to issue directions to vessels. This authority is used prudently and only when dictated by existing conditions.

### 2.3.3 Additional VTS Functions

In addition to these basic traffic service functions the Puget Sound VTS will relay messages between Coast Guard units and between vessels and on-shore company installations, when it does not interfere with the basic functions. The VTS also handles and passes information about Marine Events to both VTS participants and recreational vessels. During the fishing season, the Puget Sound VTS prepares two messages hourly, listing the vessels in the traffic system that will transit fishing areas open for that day. These messages are broadcast hourly by Group Seattle and Group Port Angeles.

The Puget Sound VTS and the Vancouver VTMS pass marine information back and forth over a teletype and a direct (hot line) telephone. The teletype is used for notification that a vessel will be entering the other's system within the next 30 - 60 minutes and for less immediate information transfer, such as

an aid to navigation discrepancy. The hot line is used for passing a vessel to one system at the time it leaves the other.

To be able to perform the VTS functions, watchstanders also perform such support functions as training and preparation and dissemination of records, reports, and messages.

## 2.4 Staffing and Scheduling

### 2.4.1 General Staffing

At the time of this study, the Puget Sound VTS had the following complement of 28 operational personnel, 7 officers and 21 enlisted:

1 - CDR - Commanding Officer
1 - LCDR - Executive Officer
5 - LT - Watch Supervisors
1 - RDCS - Traffic Center Supervisor
3 - QMC - Watchstanders
1 - QM1 - Watchstander
2 - QM2 - Watchstanders

3 - QM3 - Watchstanders

3 - RDC - Watchstanders

3 - RD1 - Watchstanders

4 - RD3 - Watchstanders

1 - YN2 - Administration and Supply.

Each watch section included one officer, at least four watch-standers qualified on all positions - Primary Communicator, Plotter, Radar Operator and External Communicator - and one or more day workers and/or trainees.

### 2.4.2 Selection

Full Lieutenants with seagoing experience as Operations Officer on a High (or Medium) Endurance Cutter, or as Commanding Officer of a Patrol Boat, are needed as Watch Supervisors. Anyone with average or above average proficiency and due for a shore assignment may be selected for VTS duty, although consideration is given to those who volunteer for the assignment. In general, VTS watchstander assignments have been made from Radarman and Quartermaster ratings. A normal tour of duty is three years.

### 2.4.3 Training

Training is primarily on-the-job. Briefings and orientation trips are arranged, but there is no formal schedule of classes. Each trainee is given 33 items of achievement to accomplish at his own pace. These achievement requirements lie in the following areas:

- Knowledge of manuals, rules and regulations
- Knowledge of the VTS area
- Knowledge of VTS procedures
- Demonstrated ability to operate VTS equipment
- Demonstrated ability to work each VTS watchstander position.

The trainee reads the materials provided, rides vessels in the system, observes watchstanders at work, and finally occupies each watchstander position under the supervision of a qualified watchstander. During this process, the trainee is rated and certified on each achievement requirement by a supervisor. When all requirements have been met, the trainee is examined and certified as a qualified watchstander by two CPO's, the Senior Watch Officer, the Executive Officer, and the Commanding Officer. This process generally takes 6 to 8 weeks, although occasionally

a trainee may fail to qualify. Generally, it takes up to 6 months for a watchstander to become fully proficient.

### 2.4.4 Work Schedule

There is a regular rotation of watch personnel through the three eight-hour watch shifts and days off so that each watch crew's membership varies according to the schedule. The watch schedule for each individual typically consists of four shifts on and three days off for the three shifts of 0000-0800/0800-1600/1600-2400, with an additional eight-hour watch (dayworker) on the day shift. The watchstander averages 40 hours of watch duty per week (see Table 2-1.) During a watch, the watchstanders rotate through the positions of Plotter, Primary Communicator, External Communicator, and Radar Operator, spending about 2 hours at each position.

TABLE 2-1 INDIVIDUAL WATCHSTANDER WORK SCHEDULE

| Day | 2300-0700 | 0700-1500 | 1500-2300 | Dayworker |
|---|---|---|---|---|
| 1 | RDC Smith | | | |
| 2 | RDC Smith | | | |
| 3 | RDC Smith | | | |
| 4 | RDC Smith | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | RDC Smith | | |
| 8 | | RDC Smith | | |
| 9 | | RDC Smith | | |
| 10 | | RDC Smith | | |
| 11 | | | | RDC Smith |
| 12 | | | | |
| 13 | | | | |
| 14 | | | RDC Smith | |
| 15 | | | RDC Smith | |
| 16 | | | RDC Smith | |
| 17 | | | RDC Smith | |
| 18 | | | | |
| 19 | | | | |
| 20 | | | | |
| 21 | RDC Smith | | | |
| 22 | RDC Smith | | | |
| 23 | RDC Smith | | | |
| 24 | RDC Smith | | | |
| 25 | | | | |
| 26 | | | | |
| 27 | | RDC Smith | | |
| 28 | | RDC Smith | | |
| 29 | | RDC Smith | | |
| 30 | | RDC Smith | | |

## 2.5 Operating Positions

The Puget Sound VTS operates from a Vessel Traffic Center (VTC) located in Seattle, WA. The VTS provides its services by assigning various activities to the following operating or duty positions: Primary Communicator, Plotter, Radar Operator, and External Communicator. The term "watchstander" will be used to refer to any of these positions. A basic watch section is comprised of one person for each duty position and a Watch Supervisor. In addition, an extra watchstander, a "day worker", may be assigned on a day shift, and one or more trainees may be performing watchstander duties under qualified supervision.

### 2.5.1 Watch Supervisor

The Watch Supervisor is an officer who is responsible for the total VTS operation during a watch, having the responsibilities of Officer of the Deck (OOD) as defined in USCG Regulations (CG-300). The Watch Supervisor is the direct representative of the Commanding Officer, and for emergency situations has been delegated the traffic control authority of the Captain of the Port (COTP.) The Watch Supervisor stays continually aware of all activities of the VTS during his watch. He assigns his personnel to the various operating positions, supervises their

performance, and rotates position assignments as circumstances require. Circumstances beyond the scope of control of the watch-standers are referred to the Watch Supervisor; in turn, he notifies the Commanding Officer or other authorities of matters beyond his scope of control. He is also responsible for internal unit safety, physical security, and the training of his watch section personnel.

The Watch Supervisor has the authority to draft and release messages and is responsible for proper message composition, dissemination and filing. He is responsible for the preparation and dissemination of reports of violations of federal regulations and restrictions of vessel movements. He must also maintain the following records: Anchorage Assignments Record, Daily Unit Log and Communication Center File. The Watch Supervisor is also responsible for the proper operation of all communications recordings and the proper keeping of vessel status cards.

### 2.5.2 Primary Communicator

The Primary Communicator conducts all communications with vessels in the area, receiving position and status reports and issuing advisories. The duties involve monitoring, anticipating, informing, cautioning and directing all the traffic participating

NAME Margaret Foss

DESTINATION Seattle

ETA 0800 PT.JEFF0400 | TERM

SOA 84.5

DEPART PTS 1845

TUG FRT TKR GOV FY FV

OIL MT HAZ CHEM MISC

LOA/200/13 BG 2RB

NOTES

PT JEFFERSON 0400--SLOW DOWN

| | | |
|---|---|---|
| 78 JAN 24 | 18:59 | PTS |
| 78 JAN 24 | 20:26 | C |
| 78 JAN 24 | 21:51 | 1/2N. RB |
| 78 JAN 24 | 23:22 | PART.PT. |
| 78 JAN 25 | 02:34 | PNP c/s4.5 |
| 78 JAN 25 | 05:11 | SH |
| 78 JAN 25 | 07:12 | BAY |
| 78 JAN 25 | 07:49 | |

OUT EWW

*GPO 798-559

FIGURE 2-2. EXAMPLE OF A VESSEL STATUS (TRANSIT) CARD

in the system. When a vessel enters the system it reports by radio-telephone to the Primary Communicator or is detected by radar and called. The Primary Communicator manually prepares a vessel status card (see Figure 2-2) containing such information as:

Name of Vessel
Position of Vessel
Destination
Estimated Time of Arrival (ETA)
Speed of Advance (SOA)
Departure Location
Type of Vessel (Tug, Freighter, etc.)
Cargo (oil, hazardous chemicals, etc.)
Overall Length (LOA, for towing vessels)
Number of Barges (BG)
Any condition on the vessel that may
  affect its navigation in the VTS area.

Necessary remarks about the vessel are made on the center section of the card to help the relieving watch understand the full story concerning the vessel. The lower section of the card can be time-stamped (punched) in a special device and is annotated as specified below:

Each time a required report is made,
when unable to establish communication
with a participating vessel,
when a vessel commits a violation,
when special circumstances exist with
a participating vessel,
each time, communications load permitting, traffic information is passed to a participating vessel,
when a vessel fails to check out, and
when the final report is made.

The time of the final report is circled, and a line is drawn from the circle to the lower left of the card, where the checkout position is written. The reverse side of the card is punched and annotated on the following occasions:

After notifying Coast Guard authorities of USSR vessel movements,
when vessel movements are reported to the Vancouver VTMS by teletype, and
when a card is made up for the Deep Draft Port Location File.

The Primary Communicator continually monitors the traffic situation as represented on the plotting board. He must anticipate future traffic situations by mentally extrapolating from the current situation. This involves prediction of passing, overtaking, and crossing situations primarily. Present position and SOA are used to dead-reckon future positions with modifications for expected changes. Some changes are based on reported intentions; others depend on the watchstander's experience--for example, knowing where vessels will typically speed up or slow down. Where available, monitored radio communications and radar imagery are used to verify and correct plot expectations and to detect unexpected or unreported situations that require changes in anticipated events. An additional source of information for the Primary Communicator is the traffic knowledge of the other watchstanders and the supervisor. Therefore, every person in the watch section, regardless of his position and other duties, shares responsibility for the accuracy of the traffic information.

The Primary Communicator informs the vessels of relevant traffic situations by providing traffic advisories. Under this mode, the role of the VTS terminates with the passage of information to the vessel. Every vessel is provided individual advisories through VHF-FM radio transmissions. An advisory may contain any or all of the following elements:

Anticipated traffic (meeting, overtaking
 or crossing),
fishing vessel concentrations,
discrepancies in aids to navigation,
channel hazards or obstructions,
weather warnings and information,
traffic controls, and
any other information which may affect
 vessel traffic safety or the port.

A traffic advisory is provided each vessel as it enters the VTS system, at every movement reporting point, and at any other time when it is apparent that changing conditions warrant it.

A typical advisory follows: "HARRY M. this is SEATTLE TRAFFIC; the display shows the PUGET working off the firedocks in the west waterway, the EVCO BREEZE is headed up waterway to Keiser, the THYLENE W. is inbound in the bay, she'll be going up to Lockheed docks and the EXPRESS, light tug inbound, is going to West Anchorage. Over."

The Puget Sound VTS operates as a mandatory advisory navigational service and is authorized to issue directions to vessels under conditions of vessel congestion or other hazardous circumstances in the VTS area. Such control is available over all vessels operating in the VTS area, and the control authority is vested in the Watch Supervisor to insure effectiveness. This authority is used prudently and only when dictated by existing conditions. A direction will generally include a statement imposing the necessary restrictions and a description of the circumstances requiring them.

A typical directing advisory follows: "BAXTER B. this is SEATTLE TRAFFIC. Due to severe channel congestion north of Pillar Point one and one-half miles, proceed at reduced speed; do not overtake the tug SEALAND".

### 2.5.3 Plotter

The Plotter receives information from the Primary Communicator either through vessel status cards or direct voice communication. For each new vessel, a model is prepared. The model consists of a hull on which four data tiles are vertically stacked. Hulls are thin plastic blocks, 2 and 5/8 inches long by 1/2 inch wide, shaped like a vessel---blunt at the stern, pointed

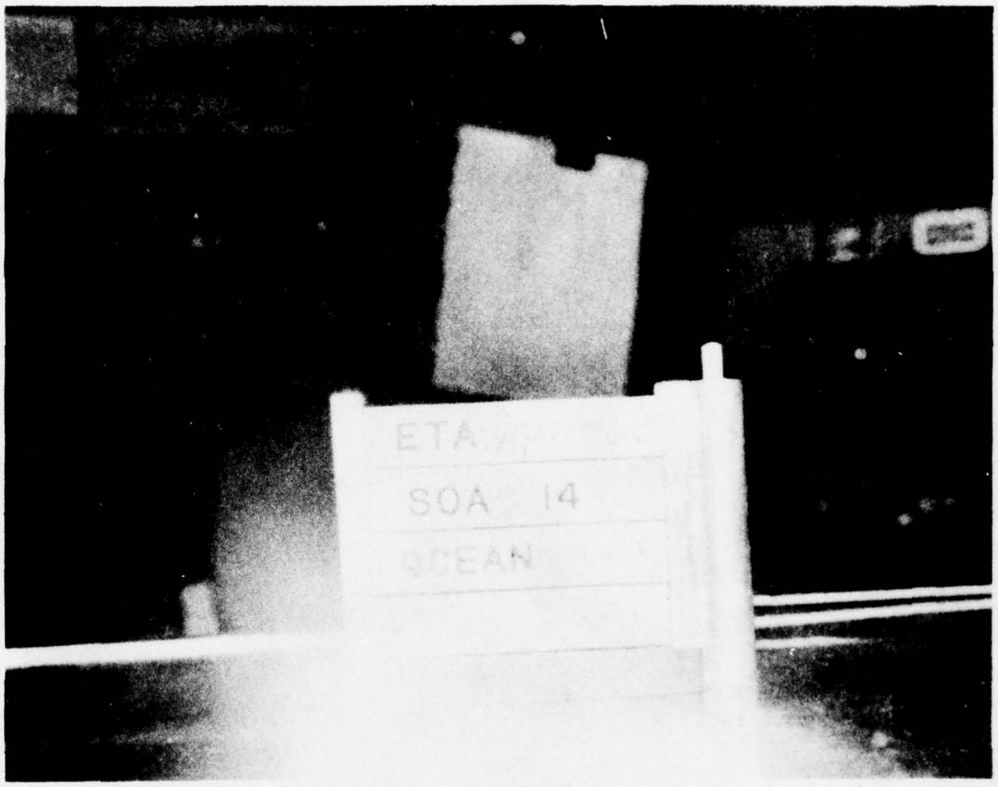


FIGURE 2-3. COMPLETED VESSEL MODEL

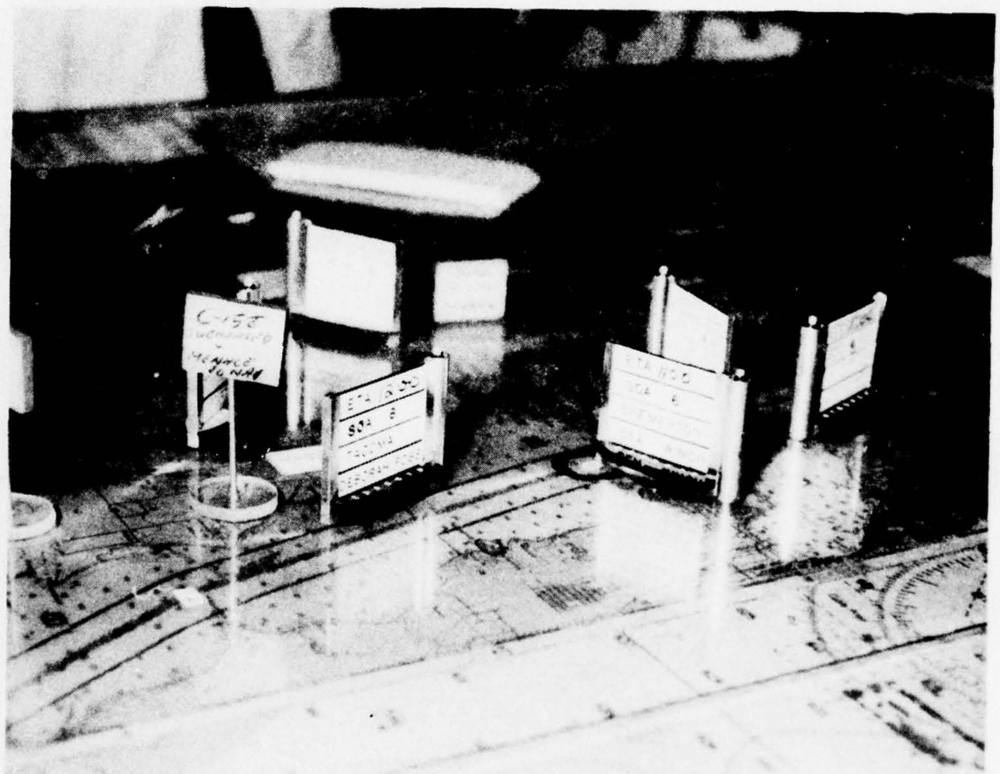

FIGURE 2-4. VESSEL MODELS AND NAVIGATION AIDS ARRANGED ON D.R. DISPLAY TABLE

at the prow. The hulls are color coded to represent various types of vessels. The data tiles are white rectangles about the size of the hull. Some tiles are pre-labelled in black letters; others are blank and are marked by the Plotter with a grease pencil. The order of information on the data tiles from top to bottom is: ETA, SOA, destination, and name. Figure 2-3 shows a typical vessel model.

Models are placed on the plotting table with the prow at the vessel's location on the map. Additional markers can be placed to represent aids to navigation. Figure 2-4 shows several models and markers on the plotting table.

The Plotter's primary responsibility is the maintenance of a complete and up-to-date plot of all vessels participating in the VTS, noting their direction, destination, and estimated time of arrival (ETA) at the next reporting point. Plotting vessel traffic involves a series of vessel entries, exits and updates of the table display. The Plotter advances each vessel model through a dead-reckoning (DR) procedure every 15 minutes. In addition to this scheduled update, he moves the models or corrects their data in response to new vessel information from radio communications and radar surveillance. Thus, the Plotter, like the Primary Communicator, must continually cross-check the displayed traffic against other available information.

The plotting procedure is a team effort in which each member monitors and, either directly or through the Plotter, updates the traffic display. The Communicator and Watch Supervisor, located close to the Strait of Juan de Fuca, usually aid the Plotter in updating this part of the display. The External Communicator assists in updating the Tacoma-Bremerton part of the display, to which he has easier access. The Plotter covers all parts of the display table, frequently leaving his designated position to operate on other parts. The relative positions of the Watch Team around the plotting table are shown in Figure 2-5.

When a vessel leaves the system, the Plotter removes and dismantles the model, cleans the tiles, and stores the parts. The Plotter also handles direct telephone communications with the Vancouver VTMS.

### 2.5.4 Radar Operator

The Radar Operator monitors four radar repeaters (scopes) in order to verify and correct vessel identification and status data through visual inspection of the traffic display or through communications with the Plotter or Primary Communicator. A radar update occurs on an irregular basis and is usually performed by the Plotter. The initiation of such an update is made by either the Radar Operator or the Plotter, involving one or more vessels and the transfer of current radar data to the plot. This transfer can be done in two ways: (a) The Plotter may look at the radar scopes directly and update his plot, or (b) the Radar Operator may compare the plot and his radar and tell the Plotter of any discrepancies, including unidentified vessels. Sometimes the Radar Operator plots radar-observed traffic on a map overlay which he hands to the Plotter. The Radar Operator notifies the Watch Supervisor of any potentially hazardous situations.

Once each watch a Radar Operator makes a calibration check of each of the 4 radar sites, entering data in a log as information for maintenance. Qualified radar technicians may make tuning adjustments at the remote sites from their VTC position.

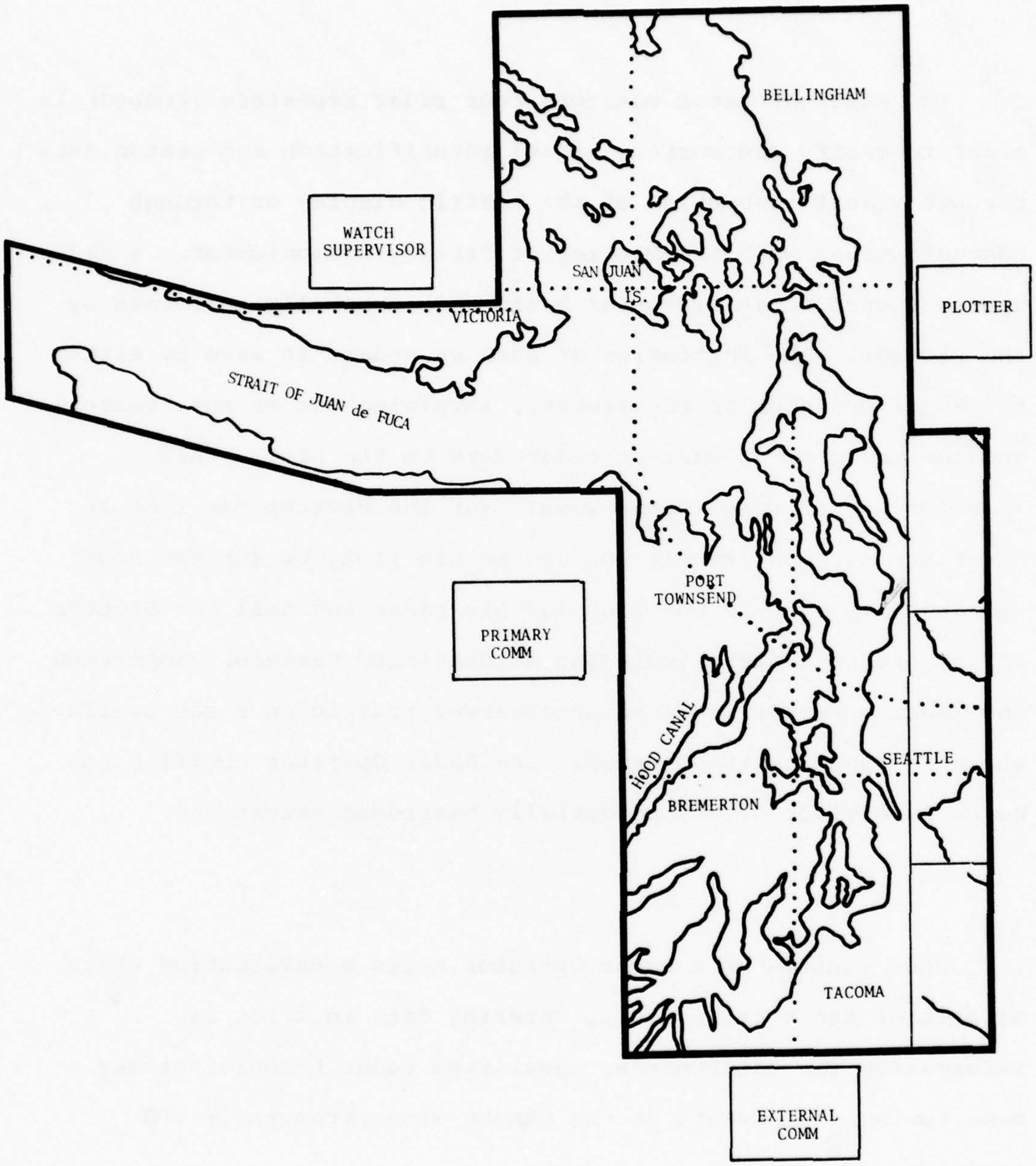


FIGURE 2-5. WATCH POSITIONS RELATIVE TO THE PLOTTING TABLE

### 2.5.5 External Communicator

The External Communicator is responsible for information in and out of the VTS other than the direct radio communications with vessels. He receives incoming telephone calls and operates the teletype between the PSVTS and the Canadian VTMS in Vancouver, BC. The External Communicator records in a vessel transit log the name, destination and ETA for vessels currently in the Puget Sound VTS. The information is tape-recorded every hour. The general public as well as pilots, dispatchers, agents, owners, and U.S. Customs and Immigration, can telephone for this information. The External Communicator assists the Plotter during high vessel traffic periods; during the fishing season, he prepares the Fishing Vessel Traffic Advisory Broadcast, and he files the vessel transit cards accumulated on the previous watch by vessel type and date/time.

### 2.5.6 Information Flow

Figure 2-6 shows the basic pattern and modes of information flow in the PSVTS. A vessel reports its position by radio to the Primary Communicator, who writes the information on a card, time-stamps it, and hands it to the Plotter, who updates the plot. The Primary Communicator visually reads the traffic situation

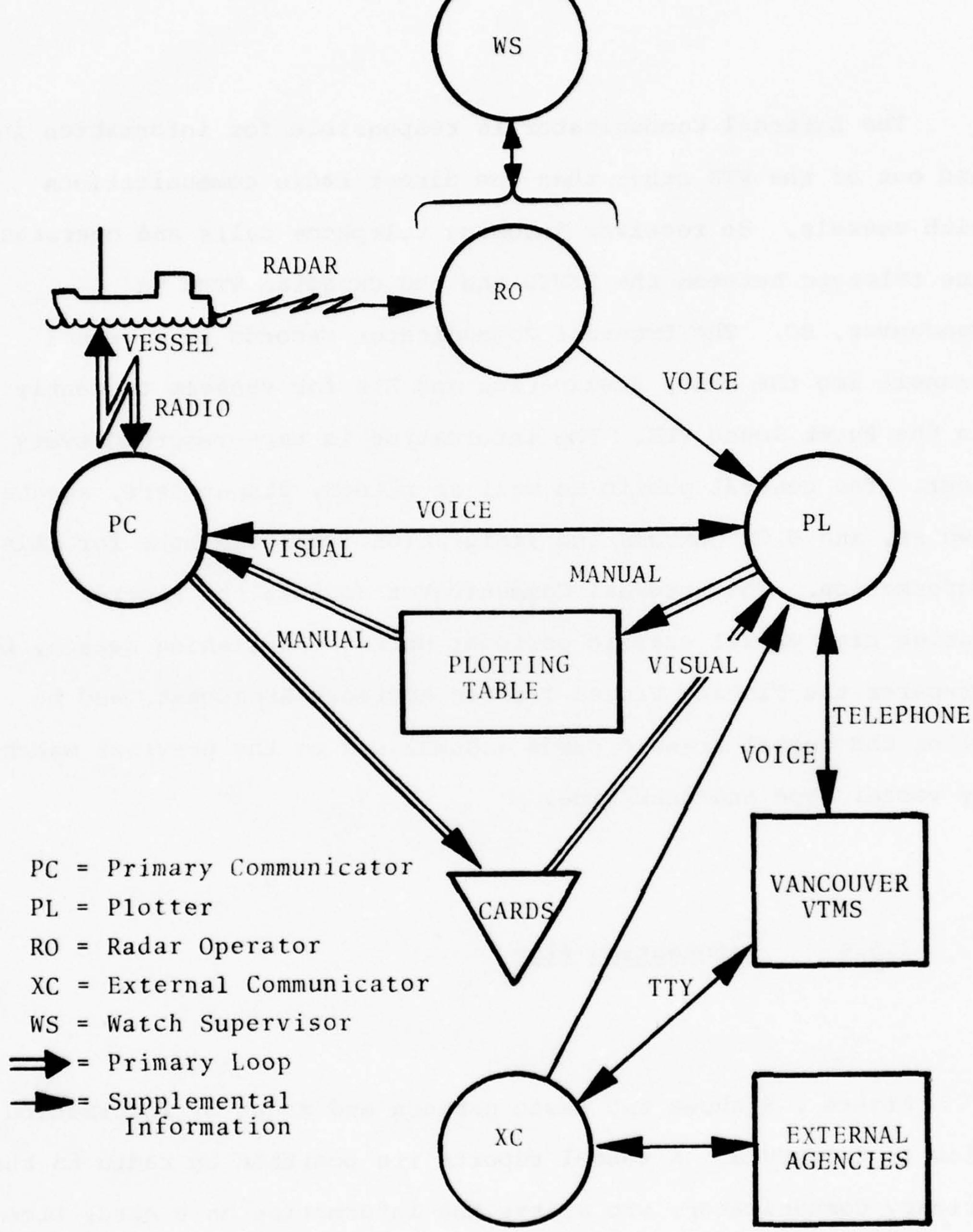


FIGURE 2-6. INFORMATION FLOW IN THE PSVTS

from the plot, mentally integrates and extrapolates the data, and provides a traffic advisory to the vessel via radio. Additional inputs to the plot include vessel position information sensed by radar and reported to the Plotter by the Radar Operator, advance information from the Vancouver VTMS received by teletype and relayed to the Plotter by the External Communicator, and vessel entry information phoned directly to the Plotter from the Vancouver VTMS. Advisories are also transmitted to Vancouver via telephone and teletype. The Watch Supervisor oversees all operations and intervenes when necessary.

In actual operation, the information flow is usually more complex. Everyone communicates by voice with everyone else, and anyone may assist the Plotter by moving models on nearby areas of the plotting table.

## 2.6 Workspace and Equipment

### 2.6.1 Workspace

Nearly all watchstander functions are performed in the Operations Room of the VTC. This room is approximately 25 by 30 feet. It is kept at a dim level of illumination, with heavy drapes covering the windows during daytime. Work positions are individually illuminated by ceiling-mounted spotlights, and the plotting table is illuminated by both ceiling lights and internal backlighting. An air conditioner provides a moderate level of continuous background noise, with a hum from the radar repeaters superimposed. Although the radar equipment is sound-shielded, the noise is loud enough at the Radar Operator's position to require him to shout when communicating with the Plotter or the Primary Communicator.

The general arrangement of duty positions and equipment in the VTC Operations Room is shown in Figure 2-7, and the positions around the plotting table are depicted in Figure 2-8. Primary duty positions are indicated. The Primary Communicator and Radar Operator work almost exclusively at these positions, but the other watch personnel move around the room considerably. In spite of assistance from other watchstanders, the Plotter

frequently moves around the plotting table to reach vessel models. The External Communicator must cross the room to monitor or use the teletypes, and the Watch Supervisor goes wherever he is needed to resolve problems.

### 2.6.2 VHF-FM Radio and Communications

The Puget Sound VTS is equipped with VHF-FM communications with dual transceivers (primary and secondary) installed at four remote sites. Guard receivers are located at each of these sites to provide a continuous guard of Channels 13 and 14. Channel 14 is the assigned VTS operating frequency for communications between the VTS traffic center and vessels. Channel 13 is reserved for bridge-to-bridge communications. Since inter-vessel communications are a rich source of information about vessel traffic and intentions, the Primary Communicator monitors Channel 13 via a speaker on his console. Channel 16, the emergency channel, is also monitored in the center. Channels 21, 22 and 81 are Coast Guard working frequencies.

The Primary Communicator position has a communication console which includes guard receiver speakers with volume control knobs, mute control buttons with mute activation lights, and transmit busy indicator lights. Also located at this position are a transmitter-receiver located below the guard receivers, a cardfile, and punch-card clock. Figure 2-9 shows the console at the Primary Communicator's position.

PC = PRIMARY COMMUNICATOR
PL = PLOTTER
RO = RADAR OPERATOR
XC = EXTERNAL COMMUNICATOR
C = COMMUNICATIONS CONSOLE
R = RADAR REPEATER
T = TELETYPE

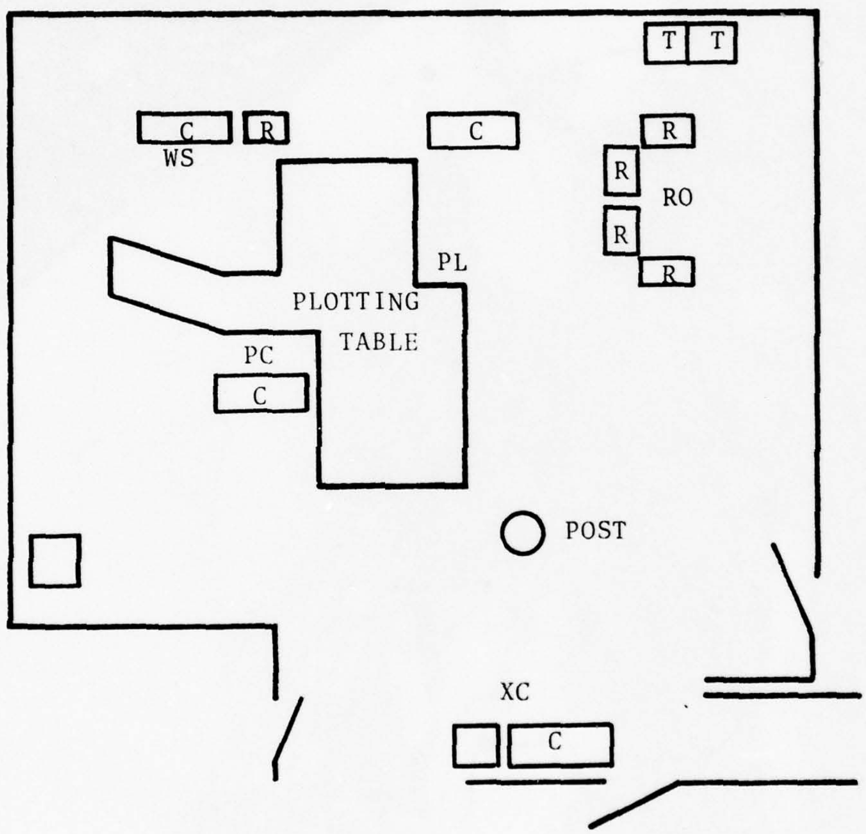


FIGURE 2-7. GENERAL LAYOUT OF THE OPERATIONS ROOM, PUGET SOUND VESSEL TRAFFIC CENTER


FIGURE 2-8. POSITIONS AROUND PLOTTING TABLE

FIGURE 2-9. PRIMARY COMMUNICATOR'S CONSOLE

FIGURE 2-10. WATCH SUPERVISOR'S POSITION

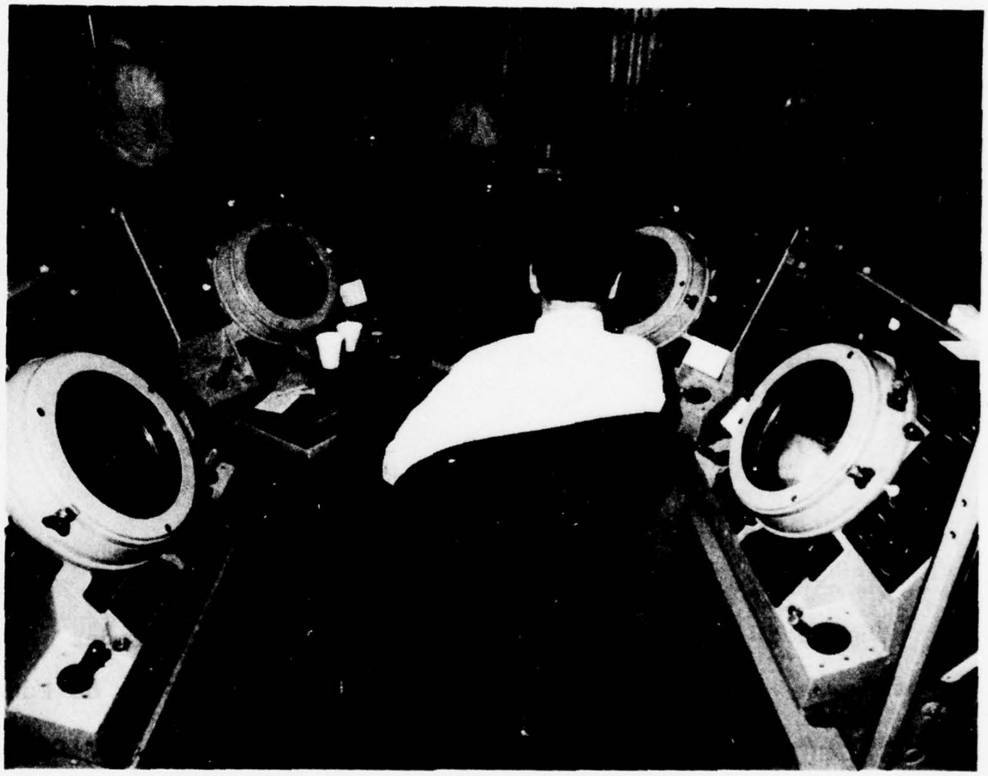

FIGURE 2-11. RADAR OPERATOR'S POSITION

The communications equipment available to the Watch Supervisor at his position include: Guard receivers, intercom, transmitter-receiver, site/channel selection controls, SAR (emergency) telephone, outside telephone on the commercial/VTS telephone service, Instacall recorder used for playback of radio-telephone transmissions, and various indicator lights. The Watch Supervisor's console is shown in Figure 2-10.

The console at the External Communicator's position contains the first four items listed for the Watch Supervisor's console. In addition to these are a "Code-a-Phone" recorder for VTS public information tapes, a Vancouver direct (hotline) telephone, and a teletype message indicator light.

### 2.6.3 Radar Surveillance Equipment and System

The Radar Surveillance System provides surface radar information from the eastern end of the Strait of Juan de Fuca through Admiralty Inlet and Elliott Bay. Four radar equipped sites (Point Wilson, Bush Point, Point No Point and Elliott Bay) provide coverage which aids in maintaining the DR plot and furnishes accurate information for operating the VMRS. Each site has two AN/SPS-51A radars. The Radar Operator's position at the VTS has four AN/SPA-66B twelve-inch PPI watchstander's

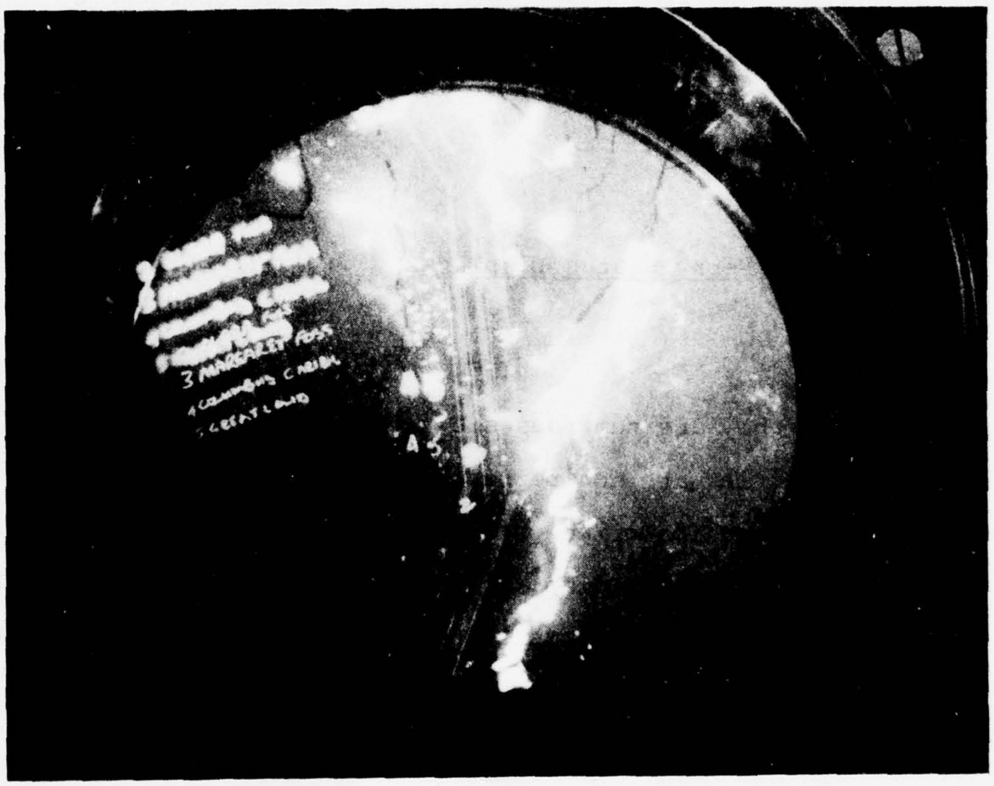


FIGURE 2-12. RADAR DISPLAY

indicators, one for each radar site. The Watch Supervisor has one AN/SPA-25 indicator, which is capable of displaying any of the four sites, and an RFL Tone Transmitter which permits switching of remote site radars in the event of failure of the online radar. Also contained in the system is a transceiver which provides an additional voice circuit to the four remote sites. A status panel gives basic information as to radar status, fire, generator power, etc.. The Radar Operator's position and a view of one radar display unit are shown in Figures 2-11 and 2-12.

### 2.6.4 Ferry Status Display

Because they are numerous and are on fixed routes and schedules, ferries are not represented by models on the plot. The Primary Communicator keeps track of ferry status with a small, locally produced display device, set on the plotting table in front of the Primary Communicator. This Ferry Status Display (see Figure 2-13) is a small box with a front panel containing a three-way toggle switch between a pair of indicator lights for each of 9 ferry routes. When a ferry notifies the VTS of an eastbound departure, the Primary Communicator throws its switch to the left, illuminating an amber light; when he receives notification of an arrival, he throws the switch to the center,

turning off the light; with a westbound departure, he throws the switch to the right illuminating a red light.

## 2.7 Events in a Routine Sequence

This study is limited to routine VTS operations. Here we will describe briefly the sequence of events as a vessel makes a normal transit through the system. This same information is diagrammed in detail in Appendix A in the form of Operational Sequence Diagrams.

### 2.7.1 Entry

A vessel subject to PSVTS regulations generally calls "Seattle Traffic" to initiate a transit. If no other vessel is awaiting a reply from the VTC, the Primary Communicator answers. The vessel is required to make an initial report at least 15 minutes before entering or beginning to navigate in the VTS area. An initial report consists of the status items listed in Section 2.3.1 of this report. During this time the Primary Communicator writes the vessel status information on a vessel status card, which he time-punches and hands to the Plotter, who begins to build the model for this vessel's transit. Upon completion, the model is placed at the check-in location, the data card is returned to the primary Communicator and inserted in a card file.

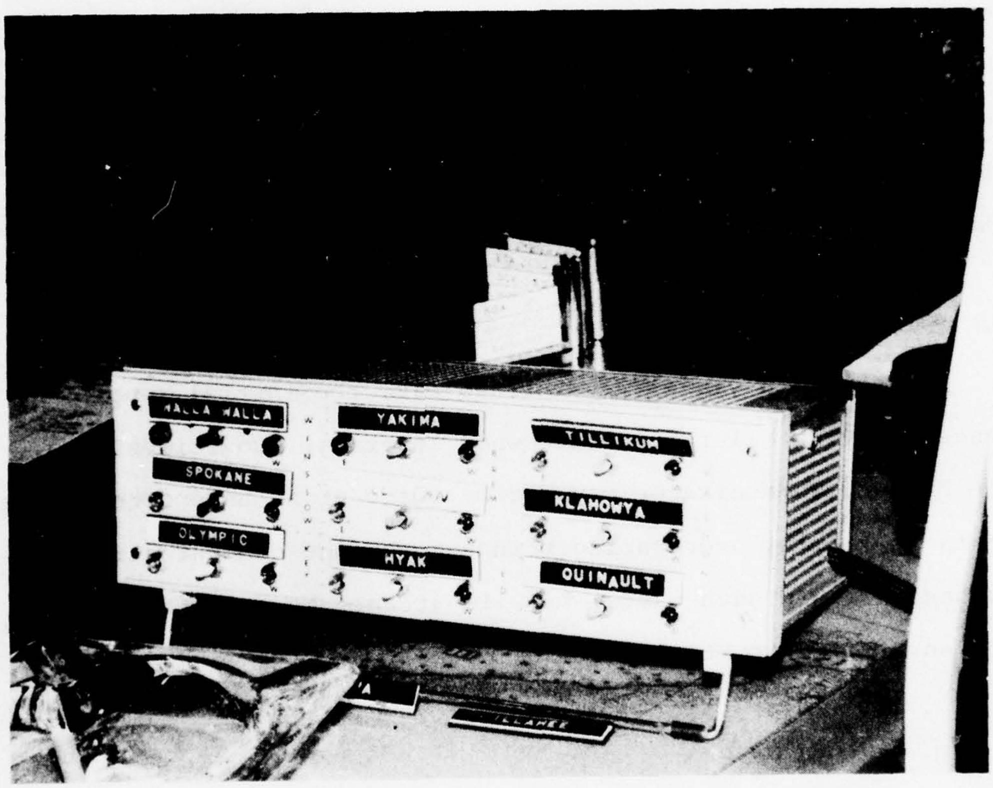


FIGURE 2-13. FERRY STATUS DISPLAY

When the vessel actually enters the system, the pilot or master notifies the VTC. The Primary Communicator retrieves the status card and records the SOA and any new data onto the card. While listening to the vessel report, he scans the plotting display table, then acknowledges and gives a traffic advisory. Following this transmission, the Primary Communicator time-punches the card thereby recording the date and time of entry into the system. The card is passed to the Plotter who copies new information onto the model tiles, such as SOA, and returns the card to the Primary Communicator to be refiled. The vessel is now entered into the system and is manually updated by the Plotter through dead-reckoning on the recorded SOA every 15 minutes.

Sometimes a vessel may fail to make the initial report, instead giving all information when entering. Sometimes, too, the Primary Communicator may become aware of an unreported vessel in the system by overhearing bridge-to-bridge communications on Channel 13. In such cases, he will attempt to call the vessel and enter it into the VMRS.

The Puget Sound VTS is advised by teletype of vessels enroute to their area by Vancouver VTMS at least 30 minutes prior to the vessel's entry. The External communicator retrieves a teletype copy of the communications and notifies the Plotter and

Primary Communicator of the transit. A model and a vessel transit card are prepared and stored. Likewise, the Puget Sound VTS notifies Vancouver at least 30 minutes before a handoff to Vancouver. When the vessel checks out, the Primary Communicator informs the pilot of the Vancouver radio frequency and reports this event to the Plotter, who notifies Vancouver through a "hot line" telephone.

2.7.2 Transit

While underway in the VTS area, a vessel may report its position under any of the following circumstances:

Vessel requests information from the VTC.

VTC requests information from the vessel.

Vessel routinely reports passing a designated reporting point. (Where there is no radar coverage, or at radar area boundaries, 9 reporting points, shown in Figure 2-1, have been specified. Additional reporting points may be designated by the watchstander if needed.)

Vessel reports changing traffic lanes.

Vessel reports a change in speed of over 1 knot.

Primary Communicator locates the transit card in the card file, time-punches the card, locates the vessel model on the plot and writes the new data on the card. The vessel is then provided a traffic advisory of conditions that he will encounter during

the next 30 minutes. The card is passed to the Plotter who changes the ETA data on the model, updates the position of the model and also changes the SOA. The transit card is returned to the Primary Communicator and inserted in a card file.

Whenever such a report is received, the various updates are carried out by the Plotter during a vessel transit in addition to the updates performed at checkpoints. The Plotter advances the DR plot of each model every 15 minutes. A radar update is done intermittently verifying and updating (if necessary) the vessel position displayed on radar with that represented on the DR plot. When a position discrepancy is significant, the Plotter informs the Primary Communicator. The vessel is then contacted by radio in order to determine actual position. The Watch Supervisor decides what further action is needed and logs the incident.

### 2.7.3 Exit

Upon completion of a vessel's transit, the vessel calls the VTS and reports the arrival at its destination. The Communicator locates the card in the card file, time-punches it, writes the final entry and passes the card to the Plotter. The Plotter removes the model from the display and erases it for future use.

For an inbound deep draft vessel, the Primary Communicator additionally makes up a new status card, time-punches it, and stores it in an in-port location file. The old card is annotated, time-punched, and passed to Plotter to be stored. When a vessel is bound for an anchorage, the card is passed to the Plotter, who removes three tiles from the model, adds an anchorage tile and marks the ETD. The vessel model is stored on the plotting table, and the transit card is reviewed by the Watch Supervisor for recording vessel information in the Anchorage Listing Log.

# 3. METHOD

## 3.1 Scope

Watchstander activities at PSVTS were observed for 12 one-hour sessions from January 24 through January 27, 1978. The intervals of data collection were selected in order to provide a representative sample of traffic load and time-of-day activities. The earliest session began at 0500 hours and the latest ended at 2230 hours.

Since the purpose of the VTS is to prevent collisions and groundings and the medium for achieving this end is voice communications via the radio-telephone, it is clear that the information passed between the center and the vessels is the critical element in this process. Therefore, it was decided that the activities of the Primary Communicator, the "Voice" of the center, should be the focus of this investigation. And, since the information conveyed to the vessels and required for making relevant decisions must be stored and readily accessible, the activities surrounding the plotting board were considered to be of comparable importance. Two observers, therefore, were assigned the tasks of monitoring the activities of the Primary Communicator and the Plotter, and, to a lesser degree, activities

of the other watchstanders as their activities related to those of the Primary Communicator and the Plotter.

The basic data on Primary Communicator activities were grouped according to the following five categories:

1. Radio Communications

2. Vessel Status Cards

3. Radio Console

4. Other Watchstander Communications

5. Assisting the Plotter.

This catagorization scheme, while providing a taxonomy does not define independent activities. Any or all of the Primary Communicator activities relating to these categories could overlap.

Essentially, the Plotter has one basic task; that of maintaining the plot. Based on a variety of input sources he must assure that the models on the board accurately represent the vessels in the system with regard to position, speed, destination, and ETA. This major task was divided into the following six specific aspects of plot maintenance:

1. Vessel Entry

2. Scheduled Board Update

3. Individual Model Update

4. Vessel Tile Update

5. Vessel Exit

6. Radar Update.

These categories are, in the main, mutually exclusive although occasionally there may be coincident occurrences. For example, an individual model update may occur within the period of a scheduled board update.

Each of the above categories for both the Plotter and the Primary Communicator was further specified in the analyses, but this is the basic format for a description of their relevant major activities.

In addition to the above analyses, interviews and stress questionnaires were administered to available watchstanders during their break periods. Photographic records were made of the equipment and activities of the Center and copies of selected reference materials were obtained to cover the 4 days of PSVTS activity which were observed. To sample user opinions, several local pilots were interviewed.

## 3.2 Procedure

### 3.2.1 Traffic Data

Information on vessel traffic in the system during periods of data collection was obtained from VTS records and from vessel status cards of each sample day. The VTS records provided the total number and type of vessels active in the system for each day for the past year. Entry and exit times for the sample periods were obtained from the cards.

### 3.2.2 Channel 14 Communications

The PSVTS maintains a daily 20-channel tape recording of all official communications with the Center. On the day following data gathering a recording of the communications on Channel 14 for the target periods was made from this master tape. The relevant material from this recording included start and stop times of a communication, the name of the vessel involved, who initiated the call, and whether or not contact was made. Transcripts of the communications are not complete at this time, but an analysis of their content is planned for a later supplement.

### 3.2.3 Primary Communicator

One observer was stationed behind the Primary Communicator to observe communication-related activities. The data were recorded by making a voice narrative into a cassette tape recorder describing the activities of the Primary Communicator. Basically this involved elaboration of the five categories named above.

1. Radio Communications. Notations were made at the start and end of all communications, whether VTS was calling a vessel or vice versa; if there was a failure to make contact or a vessel was requested to wait; if a channel other than 14 was used; or if the Watch Supervisor took over communications.

2. Vessel Status Cards. Comments were recorded whenever the Primary Communicator handled the cards; when he inserted or removed them from the active or storage file, punched the time, wrote information, or passed them to and received them from the Plotter.

3. Radio Console. The main activities of concern here were those relating to adjustments to the console in order to better receive or transmit messages. They included selecting one of the four transceiver sites, pushing a button for a power boost, pushing a general transmit button, and adjusting the volume and squelch controls for the guard channels.

4. Other Watchstander Communications. Although there was a considerable amount of conversation between watchstanders, only those conversations which were deemed job related were indicated on the tapes.

5. Assisting the Plotter. This category included those activities which were nominally part of the Plotter's tasks but which the Primary Communicator could easily do under conditions of light radio traffic, (for example, aiding with a scheduled board update or an individual model update, and changing ETA, SOA or destination tiles.)

3.2.4 Plotter

A second observer, stationed behind the Plotter, was responsible for making a voice narrative on a cassette recorder of all activities relating to the plotting board. This emphasis concentrated mostly on the Plotter but, tangentially, covered activities of the External Communicator, Watch Supervisor, and Radar Operator as they related to the plot. Elaboration of the six Plotter categories included the following:

1. Vessel Entry. This included noting the time to select the base and tiles for generating a model, assembling and placing the model on the board, and receiving, processing, and returning the cards to the Primary Communicator.

2. Scheduled Board Update. This measure was simply the start and stop times for a complete, regularly scheduled, dead-reckoning update of all models on the board.

3. Individual Vessel Update. To evaluate this operation recordings were made of the time from acknowledgment of update information relative to a given named vessel to completion of the update. Usually this involved a simple position change.

4. Vessel Tile Update. Sometimes the Plotter was required to change a tile or two (e.g., ETA, SOA) for an individual update. When this occurred, the observer would indicate start and stop times for this complete activity.

5. Vessel Exit. When a vessel reported leaving the system the observer noted the time from removing the model from the board to replacing the model and cleaned tiles in their respective storage places.

6. Radar update. This operation, while usually performed by the Plotter, clearly required the assistance of the Radar Operator to indicate the occurrence of a radar update. The observer noted start and stop times from the Radar Operator's spoken notification concerning the first vessel to the Plotter's position adjustment of the last vessel.

### 3.2.5 Other Watchstanders

At various times during the sample periods activities of the Watch Supervisor, Radar Operator, and External Communicator were observed by a member of the TSC team in order to get a listing of their indidual activities. Since the activities of these watchstanders were basically in support of the Plotter, a less detailed, yet fairly complete, description was considered adequate.

While an observer was collecting data on the Plotter, related activities of other watchstanders were also noted throughout each sample period. In addition, several hours of direct observation of the Watch Supervisor and Radar Operator were recorded by another observer. These combined data provided a classification of the relevant activities of these watchstanders but were not intensive enough to provide as complete an analysis as for the Primary Communicator and the Plotter.

### 3.2.6 Narrative Transcripts

The taped data sources described above were later transcribed onto data logs where the total number of activities and their corresponding durations could easily be identified. The data from each narrative were timed and coordinated with the occurrences and durations of the VTS-vessel, Channel 14 recordings. The data logs covering each hour's session were divided into 15-second intervals. From listening to the tapes each observer tallied the occurrence of each activity with an event line under the relevant heading. The start point of the line, its length, and end point represented start time, duration, and stop time, respectively, for a given activity. From these combined data logs, summaries of VTS watchstander activities were obtained for each one-hour recording session and for the total

series. These summaries form the basis for the analyses of Section 4.

### 3.2.7 Interviews

Six individual interviews were conducted by one interviewer. Each interview generally followed the same format and covered the same topics but was open-ended in nature. The interviewee was assured that he was not being evaluated (rather, that he was helping evaluate the system), and anonymity was assured. The interview, conducted in a comfortable private office, proceeded as a conversation, with the interviewer observing the planned format but freely following up leads and probing interesting topics at his discretion. Interview durations averaged about one hour.

### 3.2.8 Stress Questionnaires

A questionnaire intended to elicit information on subjective stress was administered to 14 watchstanders. The questionnaire contained 30 items (20 on body functions, 10 on mood) that could be simply checked off by the subject. (A Copy of the questionnaire appears in Appendix C). An experimenter explained

its purpose, let the subject read the written instructions, answered questions, and then observed as the subject checked off the items. Each subject was given a packet of 16 additional copies of the questionnaires and was asked to fill them out four times daily for the next four days and to mail them back to the experimenter in an envelope that was provided. Fourteen subjects completed the first questionniare; 9 of them returned the completed packets.

### 3.3 Data Collection Schedule

The data for this study were collected from January 24 through January 27, 1978. The major recordings of watchstander activity were made according to the following schedule:

| | | | | | |
|---|---|---|---|---|---|
| 1/24 | A: | 1500-1600 | 1/26 | G: | 0500-0605 |
| | B: | 2130-2230 | | H: | 0630-0730 |
| 1/25 | C: | 0915-1015 | | *I: | 0915-1015 |
| | D: | 1130-1230 | | J: | 1515-1615 |
| | E: | 1800-1900 | | K: | 1645-1745 |
| | *F: | 1915-2015 | 1/27 | L: | 0930-1030 |
| | | | | M: | 1130-1230 |
| | | | | N: | 1530-1630 |

* Data lost due to recording malfunction.

# 4. RESULTS

## 4.1 Vessel Traffic

The plan to evaluate PSVTS watchstander performance under routine conditions was apparently successful. During data collection no extraordinary events occurred and the daily traffic load could be considered normal. Table 4-1 contains data on the average daily traffic each month at PSVTS for 1977, along with data for the sample period. The total traffic loads for the four sample days were 542, 526, 537, and 566 vessels per day, respectively. This compares favorably to an average of about 530 per day for the month of January, 1978, and an overall daily average of 540 for 1977.

Table 4-1 also gives the mean daily number of vessels per type in the system. The overwhelming majority of vessels in the system were ferries (i.e., 74 percent of the 1977 total) followed by tugs, 17 percent; freighters, 4 percent; government vessels, 2 percent; and tankers and miscellaneous vessels, 1 percent each.

TABLE 4-1. MEAN VESSEL TRAFFIC IN PSVTS PER DAY BY CLASS FOR 1977 AND SAMPLE PERIOD AND IN STRAIT OF JUAN DE FUCA INCLUDING NON-PARTICIPANTS (n-p)

| | | | | | | | | Vessels in Strait of Juan de Fuca | |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | TUG | FRT | GOV | TKR | MISC | FERRY | TOTAL | TOTAL | N-P |
| Jan | 88.2 | 22.3 | 10.3 | 3.6 | 3.3 | 395.4 | 523.1 | 35.9 | 3.9 |
| Feb | 96.8 | 22.9 | 12.4 | 3.6 | 2.9 | 397.3 | 535.9 | 37.0 | 3.2 |
| Mar | 102.6 | 21.0 | 14.9 | 4.2 | 2.9 | 397.2 | 542.7 | 38.8 | 2.9 |
| April | 104.8 | 23.3 | 15.5 | 4.8 | 2.5 | 397.2 | 548.1 | 42.2 | 2.8 |
| May | 92.9 | 20.2 | 17.1 | 3.6 | 3.5 | 404.1 | 541.5 | 40.1 | 0.8 |
| June | 98.6 | 21.8 | 18.2 | 4.1 | 5.4 | 410.4 | 558.4 | 47.0 | 1.8 |
| July | 90.1 | 22.2 | 17.0 | 4.1 | 3.0 | 407.2 | 543.6 | 46.0 | 1.4 |
| Aug | 89.3 | 22.6 | 17.5 | 4.5 | 3.6 | 408.3 | 545.9 | 45.5 | 2.0 |
| Sept | 94.8 | 21.7 | 14.6 | 4.1 | 4.1 | 405.5 | 544.8 | 43.9 | 2.0 |
| Oct | 97.7 | 23.4 | 13.0 | 4.8 | 3.4 | 391.5 | 533.8 | 40.9 | 1.7 |
| Nov | 93.7 | 22.9 | 13.5 | 4.6 | 3.2 | 393.5 | 531.5 | 42.6 | 1.5 |
| Dec | 91.3 | 24.0 | 13.3 | 4.7 | 2.9 | 393.0 | 529.2 | 40.5 | 1.7 |
| Mean for 1977 | 95.1 | 22.4 | 14.8 | 4.2 | 3.4 | 400.1 | 539.9 | 41.7 | 2.1 |
| 1978 | | | | | | | | | |
| Jan | 97.3 | 24.6 | 16.4 | 4.0 | 3.8 | 383.3 | 529.9 | 41.7 | 1.9 |
| Sample | | | | | | | | | |
| Jan 24 | 102 | 26 | 26 | 3 | 5 | 380 | 542 | 36 | 2 |
| 25 | 111 | 15 | 13 | 4 | 5 | 378 | 526 | 31 | 2 |
| 26 | 100 | 27 | 27 | 1 | 2 | 380 | 537 | 35 | 0 |
| 27 | 132 | 23 | 21 | 9 | 1 | 380 | 566 | 51 | 2 |
| Mean | 111.3 | 22.8 | 21.8 | 4.3 | 3.3 | 379.5 | 542.8 | 38.3 | 1.5 |

Although ferries account for 74 percent of the total traffic in the system they do not reflect nearly that proportion of watchstander activity. Because their routes are fixed and scheduled, cards and models are not routinely kept on their movements. During the day the ferries may or may not report their activities to the VTS and at night or at times of reduced visibility ferries report only departures and arrivals to the Primary Communicator who keeps track of their transits on the Ferry Status Display (see 2.6.4).

In the Strait of Juan de Fuca, a voluntary participation section of the VTS area, there was an average of about 42 participating and only 2 non-participating vessels per day over 1977, and comparable traffic during the sample days. Inspection of Table 4-1 reveals an increase in participation in the Strait from 90 percent in January 1977 to 96 percent in January, 1978.

Traffic data for the 4 days of this study taken from the vessel status cards, and presented in Table 4-2, show an average of 37.8 vessels per hour participating in the system with a mean transit time of 5.2 hours. The 12 sample hours are essentially the same with a mean of 38.5 vessels per hour and a range of 30 to 52.

TABLE 4-2 SUMMARY OF TRAFFIC CONDITIONS FOR DAYS AND HOURS OF DATA COLLECTION

| Sample Period | Mean Number of Vessels/Hr in System: Day 0800-2000 | Night 2000-0800 | Total | Mean Transit Time (in Hours) |
|---|---|---|---|---|
| January 24 | 40.4 | 37.4 | 38.9 | 5.78 |
| A | 39 | | | |
| B | | 32 | | |
| January 25 | 40.4 | 37.5 | 39.0 | 4.71 |
| C | 32 | | | |
| D | 38 | | | |
| E | 45 | | | |
| January 26 | 38.3 | 30.6 | 34.5 | 4.83 |
| G | | 30 | | |
| H | | 30 | | |
| J | 43 | | | |
| K | 38 | | | |
| January 27 | 41.8 | 35.5 | 38.7 | 5.54 |
| L | 52 | | | |
| M | 44 | | | |
| N | 39 | | | |
| Grand Means | | | | |
| Days | 40.2 | 35.2 | 37.8 | 5.22 |
| Hours | 41.1 | 30.7 | 38.5 | |

A summary of the mean hourly traffic participating in the system, as determined from the vessel status cards, is shown in Figure 4-1. Using the designations of 0800-1900 as daylight and 2000-0700 as night, the figure indicates distinctly fewer participating vessels at night than during the day.

## 4.2 Primary Communicator

Almost the entire repertoire of the Primary Communicator's duty activities is reactive. When a vessel initiates a radio communication (which occurred on 70 percent of all radio calls in the sample) the Primary Communicator responds by answering the call, adjusting the console, handling the cards, and/or conversing with other watchstanders, accordingly. His only non-demand activities are those associated with assisting the plotter, adjusting equipment and cards in preparation for a call, and calling vessels not recently heard from.

The various activities of the Primary Communicator were evaluated in two ways: frequency of event occurrences and event durations. The only measures taken were those that could be objectively recognized. Since time spent looking toward the plotting board may have been an evaluation of board status or simply gazing in the direction of the board with other, unrelated

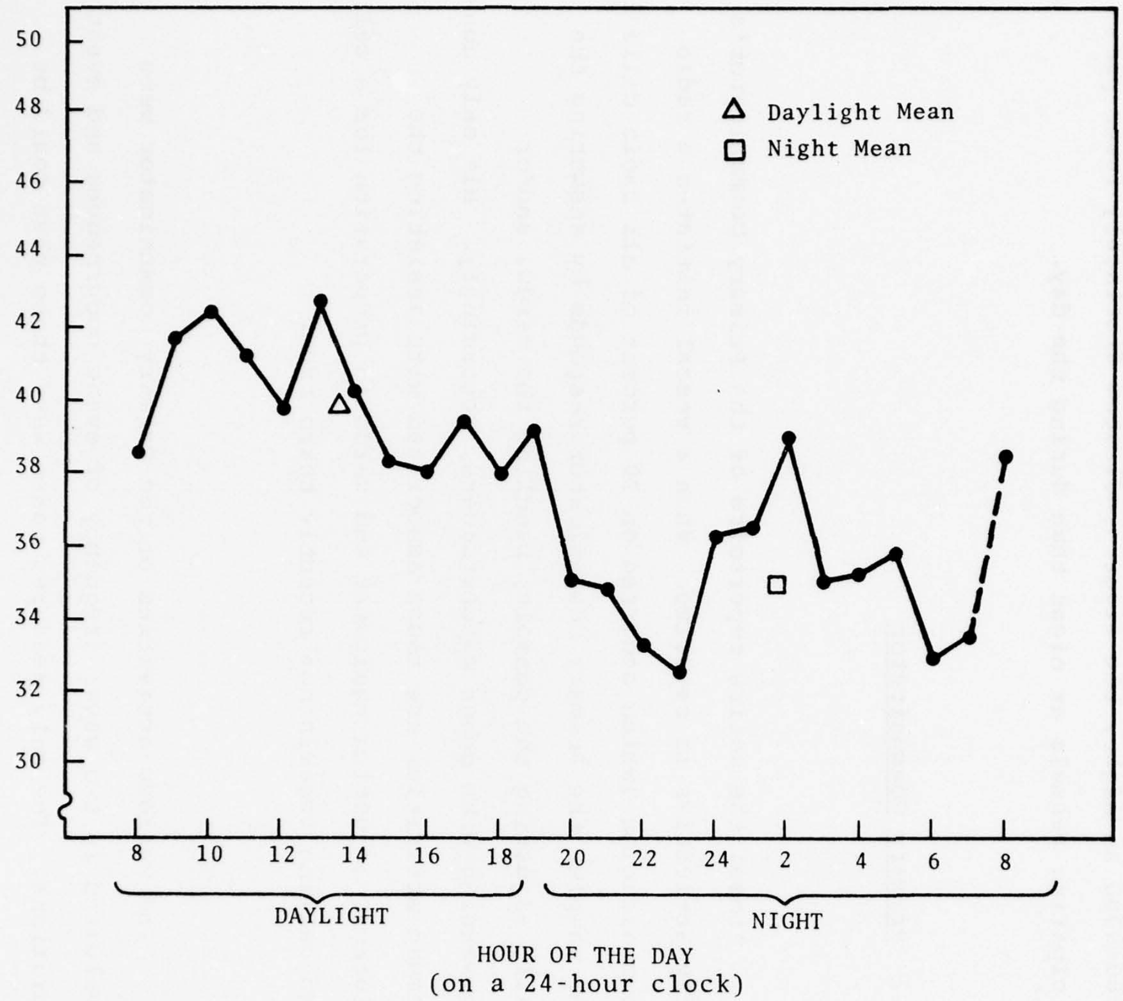


FIGURE 4-1. MEAN TRAFFIC IN SYSTEM PER HOUR OVER 24 HOURS AND FOR DAYLIGHT (0800-1900) AND NIGHT (2000-0700).N=4

intentions, estimates were made of the separate aspects of these activities.

The total number of occurrences for each of the major recorded activities along with their respective percentage of the total recorded events is presented in Table 4-3. Out of a total of 3232 recorded activities during the 12 hours of data collection 54 percent involved handling the cards, 21 percent were associated with adjustments to the radio console, and 17 percent involved radio communications. Verbal, job-related communications with other watchstanders accounted for only 5 percent of the total. From these data it is clear that the majority of the discrete activities performed by the Primary Communicator involved maintaining the vessel status cards. This is not unexpected since many separate operations are required to keep the cards current, and these cards are official records of interactions with the vessels.

Relative frequency of an activity by a watchstander, however, provides only one view of his duties, that of how often he must perform some tasks. Actual time spent in the execution of a task, activity duration, provides another equally, if not more, important and complete description of a watchstander's work load. Primary Communicator activity durations, as measured from the voice narrative tapes, are summarized in Table 4-4.

TABLE 4-3 FREQUENCY OF OBSERVED PRIMARY COMMUNICATOR ACTIVITIES

| Activity | Frequency of Occurrence | % of Total Events Recorded |
|---|---|---|
| Radio Communication | 533 | 17 |
| Bahokus Peak | 44 | 1 |
| Mt. Constitution | 153 | 5 |
| Gold Mountain | 281 | 9 |
| West Point | 55 | 2 |
| Handling Cards | 1734 | 54 |
| Remove from File | 419 | 13 |
| Put into File | 304 | 9 |
| Time Punch | 398 | 12 |
| Write on Card | 400 | 12 |
| Pass to Plotter | 145 | 5 |
| Receive from Plotter | 68 | 2 |
| Adjusting Radio Console | 689 | 21 |
| Select Site | 406 | 13 |
| Push Console Transmit | 204 | 6 |
| Push Power Boost | 60 | 2 |
| Adjust Volume Squelch | 19 | 1 |
| Communication with Others | 172 | 5 |
| Plotter | 77 | 2 |
| Watch Supervisor | 50 | 2 |
| External Communicator | 31 | 1 |
| Radar Operator | 14 | - |
| Assist Plotter with Models | 69 | 2 |
| Operate Ferry Status Display (night only) | 35 | 1 |
| Totals | 3232 | 100 |

TABLE 4-4. DURATIONS OF PRIMARY COMMUNICATOR ACTIVITIES

| Activity | Total Time (seconds) | | Function Support Time | % |
|---|---|---|---|---|
| Radio Communication | 17,276 | | 17,276 | 40 |
| Bahokus Peak | | 2,246 (13%) | | |
| Mt. Constitution | | 5,010 (29%) | | |
| Gold Mountain | | 8,292 (98%) | | |
| West Point | | 1,728 (10%) | | |
| Card Manipulation | 18,436 | | | |
| *Independent | | 3,687 (20%) | | |
| *Concurrent with Radio | | 14,749 (80%) | 3,687 | 8 |
| Communication with Others | 2,166 | | 2,166 | 5 |
| Plotter | | 1,157 (53%) | | |
| Watch Supervisor | | 547 (25%) | | |
| Radar Operator | | 215 (10%) | | |
| External Communicator | | 247 (12%) | | |
| Assisting Plotter | 765 | | 765 | 2 |
| *Monitoring Traffic | 18,886 | | 18,442 | 43 |
| Monitoring Plot | | | | |
| Passive Monitoring | | | | |
| *Other Activities | 864 | | 864 | 2 |
| Totals | | | 43,200 | 100 |

*Estimated Durations

The timed activities ascribed to communicating with others and assisting with models in Table 4-4 were generally performed when the Primary Communicator was not using the radio; however, a good part of the work with cards (writing, stamping, and passing) was concurrent with radio communications. Thus, adding card manipulation time to the other times yields a total time considerably in excess of the actual elapsed time covered by these activities. A careful study of the tapes plus the observer's memory of the observed events resulted in an estimate that 20 percent of the card-related activities occurred when the Primary Communicator was not doing anything else. This correction was applied to the card manipulation time to obtain the independent time shown in Table 4-4.

The total of all independent time measures for observed activities of the Primary Communicator accounted for 55 percent of the total time of observations. The residual 45 percent of the time was occupied by a variety of activities or lack of activity that could not be specifically identified. It was obvious to the observer that a substantial portion of this time involved monitoring the plot and guarding radio channels in order to keep up with developing traffic. Even when he was not standing and staring at a portion of the plot or when there was no talk on Channel 13 to listen to, the Primary Communicator was attentive to the situation in readiness to respond. This can be inferred from the rapidity of response when system demands did

occur and the relative rarety of participation in conversation not related to the job. Since this readiness is a part of the watchstander's reason for being on duty, its time has been credited to the monitoring function as passive monitoring. Only 2 percent of the time was judged to be occupied by activities unrelated to the job.

The largest single category of time spent in an observable activity was radio communications, 40 percent, and since this is the Primary Communicator's major function, all other activities can be said to support this activity or to assist others with their duties.

The communications may be transmitted over any of four transmission sites: Bahokus Peak, Mt. Constitution, Gold Mountain, and West Point. Almost half of all communications were transmitted over the Gold Mountain site, which had the greatest range, covering the area from Port Angeles down to Seattle with little difficulty. Bahokus Peak, accounting for 13 percent of all transmissions, was used almost exclusively for traffic in the Strait of Juan de Fuca and westward into the ocean. Mt. Constitution was used mostly to contact vessels traveling to or from Vancouver via Rosario Strait. The West Point site is designed to handle traffic in the Seattle area and down to Tacoma. In practice, however, Gold Mountain was used for Seattle

traffic more than West Point because its coverage of that area was just about as good and covered the area north better, requiring fewer site selection changes.

Although card manipulation accounts for more total time than Radio communications, it contributes far less to function support time because the majority of time spent handling the cards was concurrent with radio communications; only about 20 percent of the card manipulations were either continuations beyond the radio call or did not involve communications. The total time of 18,436 seconds of card manipulation yields a mean time of 44 seconds per card manipulation, of which, about 18 seconds were spent in actual activity with the card, including writing time. Most of the time was spent waiting for information from the vessel. Still, at these times, the Primary Communicator's major concern was with the cards; so the waiting time was allocated to the cards.

Most of the total time spent in job-related communications with other watchstanders was spent with the Plotter. Typically this interaction involved clarification of the status of a vessel in the system vis-a-vis its model. Overall, communication with other watchstanders accounted for 4 percent of total function support time.

Assisting other watchstanders accounted for 2 percent of the Primary Communicator's time. Specifically this involved aiding the Plotter with schduled updates, changing tiles, and removing a model when the vessel checked out of the system. These tasks, while normally being part of the Plotter's job were performed by the Primary Communicator.

## 4.3 Plotter

Thirty-seven percent of the Plotter's time was directly related to his primary function, maintaining the plot. He performed these duties either at a scheduled board update time (every 15 minutes) or whenever new information on the status of a vessel came in over the radio. So, in a sense, his activities were also the demand type. Unlike the Primary Communicator, however, the Plotter was subject to much less demand on the exact time at which these activities had to be executed. He did not have to respond immediately to new information. In practice, little time elapsed between awareness of a change in a vessel's reported status and the corresponding change in that vessel's model. So the Plotter, like the Primary Communicator, also spent a large proportion of his time waiting for information on the vessel traffic but, perhaps, in a less vigilant state.

AD-A062 754 TRANSPORTATION SYSTEMS CENTER CAMBRIDGE MASS F/G 5/5

PUGET SOUND VESSEL TRAFFIC SERVICE WATCHSTANDER ANALYSIS.(U)

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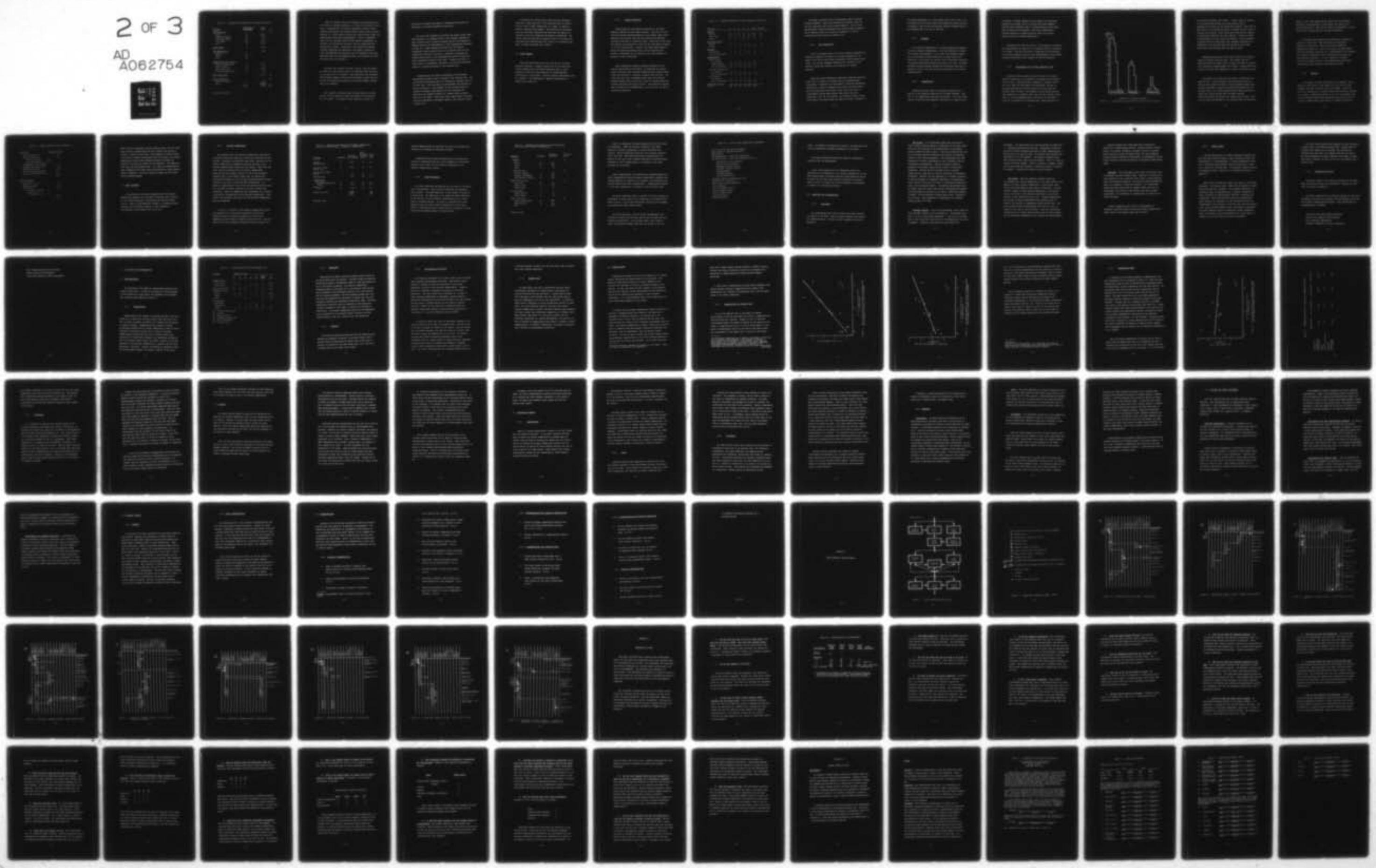

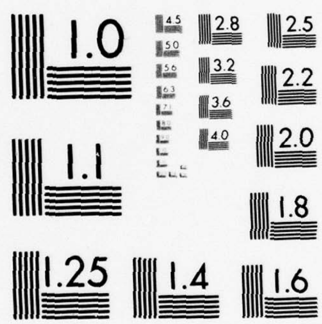


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE 4-5. FREQUENCY AND DURATIONS OF PLOTTER ACTIVITIES

| Activity | Frequency of Occurrence | Total Time | % |
|---|---|---|---|
| Plotting Board | | | 37 |
| Entry | 87 | 3,595 | |
| Scheduled Update | 49 | 5,971 | |
| Individual Update | 48 | 590 | |
| Tile Update | 140 | 3,494 | |
| Exit | 65 | 2,206 | |
| Radar Update | 20 | 1,179 | 3 |
| Card Manipulation | | *800 | 2 |
| Receive | 145 | | |
| Return | 67 | | |
| File | 78 | | |
| Communication With Others | | | 7 |
| Primary Communicator | 77 | 1,157 | |
| Radar Operator | 33 | 417 | |
| Watch Supervisor | 45 | 1,302 | |
| External Communicator | 13 | 210 | |
| Monitoring Board | | *7,776 | 18 |
| Other Activities | | | 33 |
| Vancouver Handoff | 7 | 210 | |
| Misc. | | *14,089 | |
| | 6,069 | 43,200 | 100 |

*Estimated Durations

Table 4-5 contains both the frequency and duration data for the Plotter's recorded activities. A total of 49 percent of his time is accounted for in directly observable activities which comprised maintaining the plotting board, working with the Radar Operator in a radar update, handling the vessel status cards, and communicating with other watchstanders. Based on inferences drawn from the recorded data and from observer impressions, an estimate of 18 percent of the total time was associated with monitoring the board. Essentially, this monitoring activity included inspecting the position of the models, listening to radio transmissions and verifying any new information with data associated with the corresponding model, and arranging the tiles for future use on new models.

The mean time required to enter a vessel, from the moment the model base was selected until the completed model was placed on the board, was 41.3 seconds. Mean statistics from scheduled, dead-reckoning updates taken from the observer's tapes show that it took 2.05 minutes per update and that these updates occured every 14.04 minutes.

Radar updates, involving both the Radar Operator and the Plotter, took an average of about one minute of the Plotter's time per update. The amount of time required to gather the

information to perform the update is discussed below under the discussion of the Radar Operator's activities.

The total time allocated to handling the vessel status cards (800 seconds) is an estimate based on the recorded frequency of these activities and a separate sampling of the time required to complete each of the subcategories of card manipulation presented in Table 4-5. While procedure dictates that the Primary Communicator should pass the card to the Plotter each time new information relating to the plot is obtained, in practice the Plotter often listens to the communications with the vessel and makes appropriate changes to the model. Passing the card, in these cases, is unnecessary; otherwise, card handling would have occupied a greater proportion of the Plotters time.

Communications with other watchstanders in job-related conversations occupied about 7 percent of the Plotters time. Non job-related conversations were not tallied but occupied a lot of his free time. The time spent in such behavior was included in "Other Activities". Also included in this category were the Plotter's telephone conversations with the Vancouver VTS concerning the imminent transfer of a vessel from one jurisdiction to the other. These seven calls lasted about 30 seconds each and contributed a negligible amount to the Plotter's total activity time.

Frequently the Plotter had to walk from his designated position to some other part of the plotting table in order to place or move a model, change data on a model, or observe a traffic situation more closely. This mobility was concurrent with the functional activities and thus does not appear as a separate item in the frequency and duration tabulations. The Plotter made some kind of an excursion from 9 to 24 times per hour during the observations, with a mean of 14 excursions per hour, or about once every four minutes.

## 4.4 Radar Operator

Narrative observation tapes were not made at the Radar Operator's position. However, during five of the hours that Primary Communicator and Plotter tapes were made, a third observer sat with the Radar Operator and marked observed activities on a tally sheet. Activity duration measurements were not feasible. The frequencies of observed activities are summarized in Table 4-6.

### 4.4.1 Console Activities

Three-fourths of the observed activities of the Radar Operator involved the four radar consoles. Over half of this activity involved active monitoring of the scopes, where active monitoring was counted each time the operator was observed directing attention to a specific scope. About half of the times the operator concentrated on a scope he was also marking targets on it with grease pencil. Usually this scope update required erasure of previous markings using a cloth saturated with solvent. Adjustments to the equipment were less frequent (8 percent of total activities).

Scope adjustments included changing brightness of the display, off-centering the display, or operating the cursor. Cursor activities were sometimes associated with checking radar ranges and bearings in a routine, required once each day. The cursor was also used in checking vessel speed and position. Another checking routine tuned the radar for optimum video and involved switching and tuning actions. This check was required once each watch and included making a log entry for the use of maintenance personnel.

TABLE 4-6. OBSERVED FREQUENCIES OF RADAR OPERATOR ACTIVITIES

| Activities | A | B | E | G | H | Total | Percent |
|---|---|---|---|---|---|---|---|
| Console | | | | | | | |
| Monitor | 81 | 27 | 37 | 29 | 46 | 220 | 44 |
| Mark Scope | 47 | 12 | 17 | 17 | 19 | 112 | 22 |
| Adjust | 1 | 3 | 3 | 10 | 21 | 38 | 8 |
| Site Status Rack | | | | | | | |
| Monitor | 0 | 1 | 0 | 5 | 1 | 7 | 1 |
| Adjust | 0 | 2 | 1 | 5 | 11 | 19 | 4 |
| Movement | | | | | | | |
| In Position | 7 | 3 | 9 | 4 | 12 | 35 | 7 |
| Away From Position | 1 | 0 | 0 | 1 | 0 | 2 | 1 |
| Communication | | | | | | | |
| With Plotter | | | | | | | |
| Job Related | 3 | 3 | 16 | 2 | 4 | 28 | 6 |
| (Board Update) | (2) | (1) | (1) | (1) | (0) | (5) | |
| (Not Job Related) | (0) | (1) | (0) | (0) | (1) | (2) | |
| With Watch Supervisor | | | | | | | |
| Job Related | 0 | 0 | 1 | 0 | 4 | 5 | 1 |
| (Not Job Related) | (0) | (1) | (0) | (0) | (0) | (1) | |
| With Others | | | | | | | |
| Job Related | 8 | 5 | 2 | 3 | 3 | 21 | 4 |
| (Not Job Related) | (1) | (3) | (1) | (0) | (3) | (8) | |
| References To Log | 0 | 0 | 0 | 2 | 10 | 12 | 2 |
| Totals | 148 | 56 | 86 | 78 | 131 | 499 | |

Adjustment activities varied considerably among the watchstanders observed. Some rarely touched the controls, while one did more adjusting than all the others combined. Part of this watchstander's activity constituted the required daily checkouts, but he appeared also to be tuning and checking as a way of occupying time when there was nothing to do.

### 4.4.2 Site Status Rack

A rack of equipment next to the radar consoles permitted the operator to monitor the status of the radar equipment at the remote sites and to select which transceiver would display on his scope. Use of this equipment accounted for 5 percent of the observed activities, mostly in the actuation of selector switches.

Aside from routine checking, transceiver selection was used most often as a means for avoiding delay in changing radar sensitivity. Sometimes it is desirable to raise the sensitivity threshold of a radar to eliminate sea clutter and other noise, but this Sensitivity Time Control (STC) can not be left on continuously, because weak returns from traffic are also eliminated. When STC is selected, the actuation causes a delay during which the display fades for about one sweep. However, if

the second transmitter at a site is kept set for STC, then it can be switched in at the site status rack without the delay and loss of display. Most of the rack activity observed involved using it for switching STC in or out in this way.

### 4.4.3 Movement

At the time of observation, the Radar Operator was required to stay in position continuously. Only two instances of leaving the position were observed. In one case, the operator stepped over to the plotting table briefly for a closer look at the situation; in the other, the operator took a two-minute break but had another watchstander monitor the position for him. The other observed activity involved standing up and sitting down again in position, either to see the plotting table better or to relieve cramped muscles.

### 4.4.4 Communication

Communication with other VTC personnel accounted for 11 percent of the observed activities of the Radar Operator. Over half of the communication was with the Plotter. Only five formal updates of the plot were observed, although it is required every

15 minutes. Informal updates (at the request of the Plotter) occurred a few times, and it is likely that covert updates occurred more frequently (when the Radar Observer simply noted that no changes were required.) Most other communication involved answering or asking questions about the traffic, generally with the Primary Communicator.

Considering the lack of activity in the position, relatively few conversations not related to the job were noted (11 instances in 5 hours). This fact is partly a reflection of the isolation of the Radar Operator from the other watchstanders and was almost certainly influenced by the presence of the TSC observers.

### 4.4.5 Distribution of the Radar Operator's Time

Although activity durations were not timed at the Radar Operator's position, it is possible to estimate time allocation from the data. Activities were recorded on a separate line of the tally sheet for each minute of observation, and when an activity continued for several minutes, its tally mark was extended down the sheet. The midpoint of each minute interval was assigned as an estimated time value for each activity tally. Thus, if a tally appeared alone in one block, it was given a value of 30 seconds; if it extended into a second interval, it

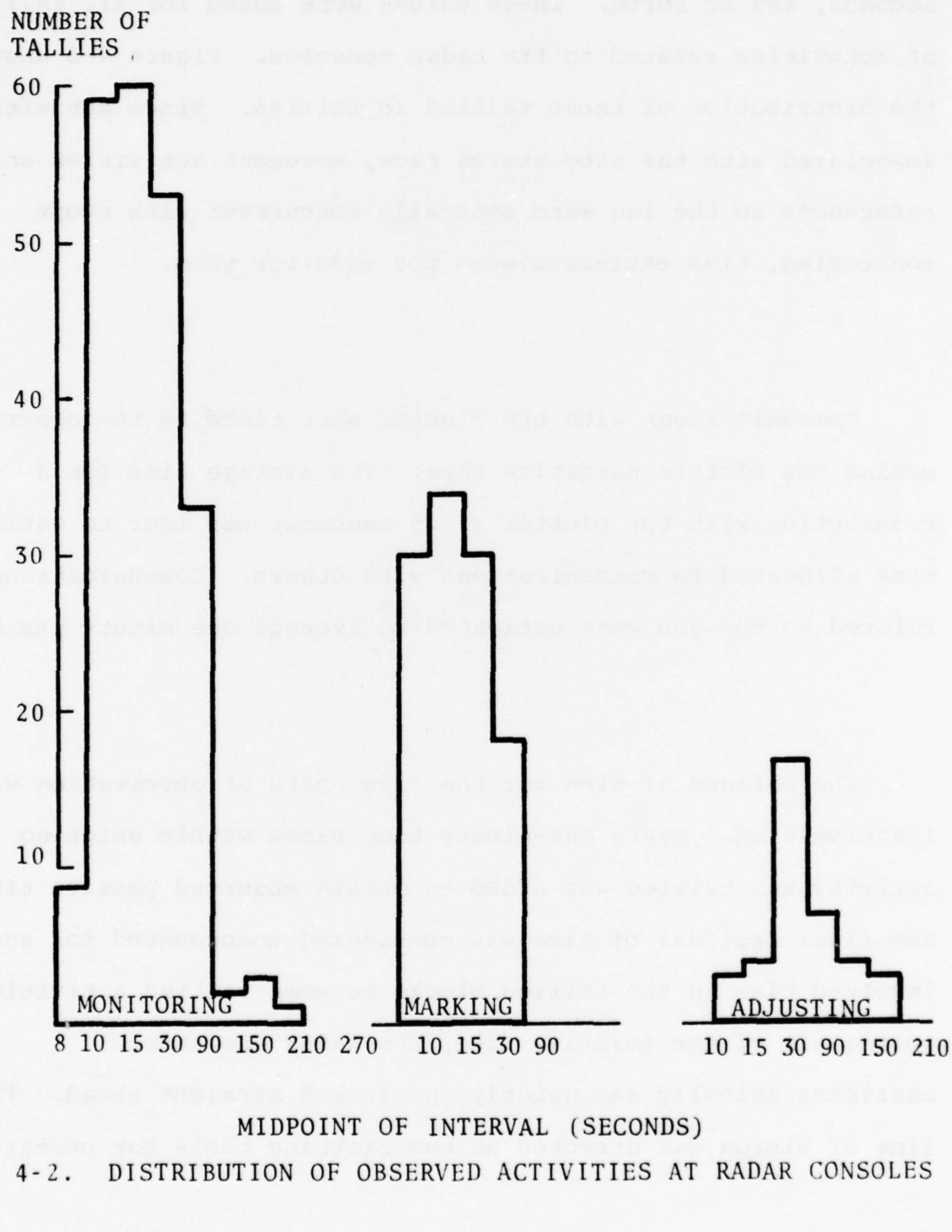


FIGURE 4-2. DISTRIBUTION OF OBSERVED ACTIVITIES AT RADAR CONSOLES

was called 90 seconds, and so forth. If more than one instance of an activity was tallied in the same minute, then a proportionate fraction of the minute was credited. Thus, each of two tallies in one minute was given 15 seconds; each of three, 10 seconds, and so forth. These values were added for all tallies of activities related to the radar consoles. Figure 4-2 shows the distribution of these tallied activities. Since activities associated with the site status rack, movement activities and references to the log were generally concurrent with scope monitoring, time estimates were not made for them.

Communications with the Plotter were timed by the observer making the Plotter narrative tape. The average time for a transaction with the plotter (12.5 seconds) was used to estimate time allocated to communications with others. Communications not related to the job were estimated to average one minute per hour.

The balance of time for the five hours of observation was inactive time. Every one-minute time block within which no activity was tallied was added to obtain observed passive time. The final residual of time was considered unaccounted for and involved time in the tallied blocks between tallied activities. During all of the inactive time, the Radar Operator characteristically sat quietly and looked straight ahead. This line of vision was directed at the plotting table but permitted

looking at the radar scopes without detectable head movement. Although it was impossible to tell whether the operator was indeed monitoring the plot and his scopes or daydreaming, we have called these inactive periods "inferred monitoring."

The various time estimates were combined and converted to percents of total time. This distribution of the Radar Operator's time over the active and inactive periods is summarized in Table 4-7. Also in the table, the same figures have been combined to show the time contributions to the relevant VTS functions: monitoring traffic, maintaining the plot, and miscellaneous activities. In this accounting, the Radar Operator's tracking activities and communications with other watchstanders were credited to maintaining the plot.

### 4.4.6 Workload

On the whole, the Radar Operator's job is passive. Only a portion of the traffic in the system is in the area of radar coverage, and that is divided among four scopes. During the periods of observation, the Radar Operator was tracking a maximum of 8 vessels. Characteristically, he sat for long periods doing nothing (inferred monitoring) punctuated with brief flurries of activity, (scope update, plot update, or problem resolution).

TABLE 4-7. RADAR OPERATOR'S TIME DISTRIBUTION

| Activities | | Percent of Time |
|---|---|---|
| Observed Monitoring | | 9.7 |
| Inferred Monitoring | | 52.7 |
| Observed Passive | 30.7 | |
| Time Unaccounted For | 22.0 | |
| Communicating With Plotter | | 1.9 |
| Communicating With Others | | 1.8 |
| Marking Radar Scope | | 18.5 |
| Adjusting Radar Equipment | | 13.7 |
| Activity Not Related To Job | | 1.7 |
| | | 100.0 |

| Function Support | | |
|---|---|---|
| Monitoring Traffic | | 62.4 |
| Maintaining Plot | | 22.2 |
| Miscellaneous | | 15.4 |
| Adjusting Equipment | 13.7 | |
| Activity Not Related To Job | 1.7 | |
| | | 100.0 |

Aside from the calibration activity already noted, the only other major activity occurred when the Radar Operator was unable to identify a return on his scope. This resulted in several checks of the plot and verbal interchanges with the Plotter, the Primary Communicator and the Watch Supervisor before the model was located on the plot far behind its true position. Two operators kept busy with job-related tasks -- one tuned and calibrated the radar frequently; the other erased and updated his radar tracking symbols frequently. The other operators simply sat and stared during inactive periods.

## 4.5 Other Personnel

The activities of the Watch Supervisor and the External Communicator support, but contribute relatively little directly to, the routine functions of monitoring and advising vessel traffic. Each of these positions, however, is discussed below, outlining the significant aspects of their respective contributions to the overall task of the VTS.

### 4.5.1 External Communicator

The observations of the External Communicator were made by an observer whose main task was to record the activities of the Plotter. Therefore, at especially busy times, activities of the Plotter dominated the observer's attention and some of the External Communicator's activities were missed. There were four basic activities tallied for the External Communicator: communicating with someone outside the VTS on the telephone, recording data in the vessel transit log, and sending and receiving information on the teletype concerning imminent vessel transits to or from the Vancouver VTMS jurisdiction. In addition, communications with others and assisting with the plot were included to obtain a measure of the more indirect job activities. Table 4-8 summarizes this information for 10 hours, 12 minutes of recorded data on the External Communicator. This sample time represents the total time the External Communicator was being observed.

A total of 15 percent of the External Communicator's time was allocated to the four basic categories of activities described above, the greatest proportion of which was in communicating with people or agencies outside the VTS. The mean duration for these activities ranged from about one minute for

TABLE 4-8. FREQUENCY AND DURATION OF EXTERNAL COMMUNICATOR ACTIVITIES OVER 10 HOURS, 12 MINUTES OF OBSERVATION

| Activity | Frequency | Duration (in seconds) | Mean Activity Duration (sec.s) | % of Total Time |
|---|---|---|---|---|
| Outside Communication | 39 | 2335 | 60 | 6.4 |
| Entriesin Vessel Transit Log | 27 | 2222 | 82 | 6.0 |
| Record Code-A-Phone Message | 7 | 491 | 70 | 1.3 |
| TTY/Vancouver | 7 | 579 | 83 | 1.6 |
| Communication With Others | | | | |
| Primary Communicator | 23 | 247 | 11 | 0.6 |
| Plotter | 13 | 210 | 16 | 0.5 |
| Assist with Plot | 25 | 250 | 10 | 0.7 |
| *Other Activities | - | 30386 | - | 83 |
| | | 36720 | | 100 |

*Residual Time

outside communications to just under one and a half minutes for operating the teletype for Vancouver handoffs.

Communicating with other watchstanders and assisting the Plotter in maintaining the plot, while important in the overall operation of the VTS, are not essential components of the External Communicator's duties.

### 4.5.2 Watch Supervisor

One Watch Supervisor was observed for two hours on the third day of observations. Both activity frequencies and durations were recorded. The Watch Supervisor is the officer in charge of a given watch. His major task is to assure the smooth operation of the VTS and to be the official representative of the Coast Guard in decision matters. Two hours of recorded data on one position cannot be safely called representative of the exact duties of that position but it does provide an indication of time allocation reasonably similar to routine duties.

TABLE 4-9. FREQUENCY AND DURATION OF WATCH SUPERVISOR ACTIVITIES OVER 2 HOURS OF OBSERVATION

| Activity | Frequency | Duration (seconds) | % of Total Time |
|---|---|---|---|
| Monitor | | | 26 |
| Board | 18 | 894 | |
| Radio | 17 | 932 | |
| Radar | 3 | 32 | |
| Communications | | | 13 |
| Vessels (Radio) | 3 | 120 | |
| Outside (Telephone) | 8 | 390 | |
| Watchstanders (Verbal) | 14 | 429 | |
| Handle Written Info | | | 11 |
| Check Ref's | 16 | 575 | |
| Write in Log | 3 | 155 | |
| Handle Cards | 4 | 67 | |
| Assist Others | | | 1 |
| Update Models | 7 | 46 | |
| Adjust Radio | 6 | 34 | |
| Other Activities | | | 49 |
| Social Conversation | 18 | 1890 | |
| Leave Station | 9 | 260 | |
| *Misc. | - | 1376 | |

*Residual Time

Table 4-9 summarizes the results obtained for the two hours of observation. Under the category "Monitor", only those activities directly recognizable as active monitoring were tallied. Passive monitoring could have been occuring virtually all of the time. This active monitoring classification (26 percent of the total time) included examining the plotting board, listening to radio communications, and looking at the radar repeater at his station.

Under communications, the observations included taking over radio communications from the Primary Communicator, speaking with outside agencies or persons on the telephone, and discussing job-related matters with other watchstanders. Communications defined in this way, accounted for 13 percent of total activity time.

The Watch Supervisor spent 11 percent of his time looking up information in one or more of the references at his console (see Table 4-10 for a list of his references), writing in the logbook, and handling the vessel status cards.

The Watch Supervisor, like the other watchstanders, was available to assist with the plot when he was not busy with more immediate requirements. In the sample taken, this occured 7 times, and occupied slightly more than one percent of the two

TABLE 4-10. LIST OF PSVTS SUPERVISOR'S REFERENCES

List of Juan de Fuca Non-participants
Watch Officer's Information Booklet
PSVTC Manual
VTS Hotword Book - Short term information
VTS Hotword Book - Long term information such as:

- Penitentiary Ferry Schedules
- Private Ferry Schedules
- Emergency Traffic Controls
- Hazardous Traffic Controls
- LNG Regulations
- Telephone Numbers
- Fishing Regulations

Equipment Repair and Maintenance Log
Local Notices to Mariners
PSVTS Seattle Safety Broadcast
Ferry Schedules
List of Merchant Vessels
*Lloyd's Shipping Index*
List of Lights (USCG)
Violation Letters
Operating Manual

hours. In addition to assisting the Plotter, he would assist the Primary Communicator by making adjustments to the radio.

The other activities tallied were those not specifically related to his job requirements.

Again, this analysis does not adequately reflect the importance of the supervisor in the overall operation of the VTS. Most significantly, the Watch Supervisor must decide the course of action for the VTS, make decisions concerning non-routine events, as well as assure that each watchstander is performing his duties in a professional manner.

## 4.6 Interviews and Questionnaires

### 4.6.1 Interviews

Six watchstanders were given in-depth interviews covering all aspects of VTS work. Their principal judgments and opinions are summarized below. Details of their responses are given in Appendix B.

VTS Service. All interviewees agreed that some kind of vessel traffic advisory service is desirable for the Puget Sound area, but their ratings of the effectiveness of the present service ranged from good to poor. Only one interviewee felt that the Coast Guard should be operating the service; the majority favored a Civil Service operation. The interviewees felt that cooperation of pilots and masters is good, although a few are consistently uncooperative. Masters and pilots generally appreciate the traffic advisories but object to being given directions. The VTS has been valuable also in relaying communications, especially in getting assistance for emergency situations. However, the VTS sometimes is a negative influence in giving erroneous or incomplete advisories, in engendering a false reliance on the part of users, in distracting attention of users, and in delaying traffic. The feeling was prevalent that at higher levels the Coast Guard neither understands the purpose nor appreciates the services of the VTS's. Additional comments included: The VTS shouldn't be doing police work. Advisories are too long. Some advisories are unnecessary (for example, passing traffic in a TSS.)

Personnel Matters. Of the six interviewees, three liked VTS duty, two were neutral, and one disliked it. The majority felt that it is not a good career assignment -- that one is not doing what he was trained for and is thus at a disadvantage in his next assignment. Generally, they would not want another VTS

assignment. All agreed that the training received at PSVTS gave t... adequate preparation for the job. Suggestions offered for selection criteria included experience in radio communications, a hearing test, and some sea duty. The present watch schedule was acceptable to all interviewees. Some specific comments were: There should be more liberty (no Day Worker). There is a loss of respect for senior grades. There is no chain of command. Chiefs are not using what was learned in training and have no incentive to progress. A person can exercise too much pressure.

VTS Duties. There was complete agreement among the interviewees that Primary Communicator is the most difficult duty position and that External Communicator is the easiest, with Plotter and Radar Operator about equal in difficulty. The most difficult aspect of being Primary Communicator is the mental strain, of Plotter is the standing and walking, and of Radar Operator is the boredom and noise level. Primary Communicators were judged to become uncomfortable when handling over 45 vessels; the Plotter can comfortably handle several more. The Radar Operator becomes uncomfortable when there are over 30 vessels in the area of radar coverage. Since the interviewees estimated that an average system traffic load is 30-40 vessels, routine operations apparently do not overload the watchstanders.

External factors that interviewees felt increase the difficulty of watchstanding include: pleasure boating, fishing fleets, bad weather, accidents, equipment failures on vessels, pilots failing to yield the right-of-way, and lane crossings. Internal factors reported as contributing to difficulties include having visitors in the VTS and having to manipulate vessel status cards.

Equipment. All interviewees agreed that the plotting table is important and gets frequent usage. However, its accuracy was rated moderate to low, especially with regard to exact position. Radar was considered important, but opinions varied considerably about its frequency of usage and accuracy. All interviewees agreed that more radar sites are needed; indeed, half of the interviewees rated radar as the function most badly needing improvement. The difficulty in concentrating on radar for two hours was noted.

Several suggestions were made for rearrangement of equipment, generally aimed at giving the Primary Communicator a better view of the plotting table and the radar.

### 4.6.2 Stress Levels

A stress questionnaire, on which respondents indicated how they felt with regard to somatic (body) feelings and mood, was administered to 15 watchstanders, 9 of whom subsequently filled out 16 additional questionnaires tracing variations in stress over a period of 4 working days. The principal response patterns are summarized below. Details of all responses are given in Appendix C.

Every index of stress was found to get worse as the workday progressed. The highest stress levels were indicated for aching and burning eyes and tiredness. Other somatic complaints (in decreasing order of magnitude) were: headache, disturbed by noise, difficulty in staying awake, backache, stiffness, and indigestion. Mood items included drowsy and uncomfortable. These stresses are attributed to such characteristics of the watchstander's job as having to stand and lean over the plotting table, glare from the plotting table, difficulty in monitoring dim radar displays, having to communicate against background noise, the tension of being responsible for a large number of vessels, and the fact that the service is mandatory.

The PSVTS stress patterns were compared to those obtained in a similar way at the Houston-Galveston VTS. Burning eyes and tiredness were highest also at Houston, but backache and stiffness were much lower (all Houston positions are seated). The general magnitude of stress appeared to be higher at Puget Sound than at Houston, in spite of the fact that Houston runs a 12-hour watch.

### 4.6.3 Interview with Pilots

Six pilots, members of the Board of Directors of the Puget Sound Pilots Association, were interviewed. (Details of this visit are given in Appendix D.)

The pilots complained of the military aspects of Coast Guard operations, the nature of citations, and the staffing of the VTS by relatively inexperienced personnel. They offered several recommendations, including:

Operate the VTS under civilian authority.
Increase the number of radio channels.
Limit reporting requirements.
Eliminate advisories on routine conditions.

Give tankers priority over tow boats.

Reduce talking on VTS channels.

Study other systems of traffic management.

# 5. DISCUSSION AND RECOMMENDATIONS

## 5.1 Team Activities

The functions of the PSVTS are accomplished jointly by the combined watch teams. To show the proportion of time allocated to each function by a Watch Team, the estimates for individual duty positions were combined in Table 5-1.

### 5.1.1 Communicating

Communications with vessels, the primary product of the VTS, account for 8 percent of the Watch Team's time; the rest of the time is spent in support activities or in waiting for the system to require activity. Communicating with vessels is almost exclusively conducted by the Primary Communicator, with the Watch Supervisor occasionally taking over to resolve a problem. Communications outside the VTC, such as routine phone calls, preparation of Code-a-Phone messages, and exchanging information with the Vancouver VTMS, account for about 3 percent of the time, conducted by the External Communicator (2 percent) and the Watch Supervisor (1 percent). General interchange of information among the watchstanders accounts for another 4 percent of the time.

## TABLE 5-1. DISTRIBUTION OF PSVTS WATCHSTANDER TIME

| FUNCTION | PERCENT OF TIME | | | | | | |
|---|---|---|---|---|---|---|---|
| | PC | PL | RO | XC | WS | WATCH TEAM | (TT) |
| COMMUNICATING | | | | | | | |
| With Vessels | 40 | | | | 2 | 8 | (13) |
| With Others | 5 | 7 | 2 | 10 | 11 | 7 | ( 5) |
| Monitoring Traffic | 43 | 18 | 62 | | 26 | 30 | (41) |
| Plotting Traffic | | | | | | | |
| Board | 2 | 40 | 2 | 1 | 1 | 9 | (15) |
| Cards | 8 | 2 | | | 1 | 2 | ( 3) |
| Radar | | | 19 | | | 4 | ( 6) |
| Miscellaneous | | | | | | | |
| Recording | | | | 6 | 2 | 2 | |
| Supervising | | | | | 19 | 4 | |
| Other | 2 | 33 | 15 | 83 | 38 | 34 | (17) |

PC = Primary Communicator
PL = Plotter
RO = Radar Operator
XC = External Communicator
WS = Watch Supervisor
TT = Traffic Team

### 5.1.2 Monitoring

Monitoring the traffic situation occupies nearly a third of the Watch Team's time (30 percent). Everyone except the External Communicator spends a considerable amount of time just keeping an eye on the traffic situation. The External Communicator frequently works at the south end of the plotting table and may also contribute to the monitoring function, but, this function was not directly observed. The Radar Operator spends well over half his time monitoring the situation to assure that the plot accurately reflects the information received by radar. The Watch Supervisor's monitoring time was credited to the monitoring function, although it could just as logically be credited to supervision. The Primary Communicator must base his advisories on his projection of the current traffic situation and thus spends between a half and a third of his time monitoring.

### 5.1.3 Plotting

The plotting function provides the data for monitoring and advising and required 15 percent of the Watch Team's time, 9 percent going to maintaining the master plot on the board, 4 percent to tracking on the radar scope faces, and 2 percent to up-dating data on the vessel status cards.

### 5.1.4 Miscellaneous Activities

The remaining 40 percent of the Watch Team's time is divided among numerous miscellaneous activities. Maintaining records utilizes 2 percent of this time (one-fourth by the Watch Supervisor, the rest by the External Communicator). Another 4 percent is credited to supervisory functions of the Watch Supervisor. The rest of the time is occupied in a variety of ways, including adjustments of equipment, reading reference materials, conversations not directly related to the job, leaving the duty post, or simply waiting for the system to require activity. Almost half of this time is associated with the External Communicator position, which functions partially as a relief duty -- a job less demanding than the others.

It should be noted that time not observably occupied by the primary functions of the VTS is not wasted time. The Watch Team is on duty to respond to demands of the system. When the system does not demand activity, the crew must still be on hand, alert and ready to meet the demands when they do come. The present analysis was limited to routine operations; much of the unoccupied time is a safety factor to assure the extra capability needed when the system is stressed by accidents, incidents, special events, unusually heavy traffic, severe weather and the like. Only after the system has been evaluated under stress can

a reliable estimate be made as to how much slack time is justifiable under routine conditions.

### 5.1.5 Traffic Team

In other VTS's, the area is sectorized, with one Sector Watchstander performing all communications, monitoring and plotting functions for his own sector. A Watch Team in these VTS's includes a Sector Watchstander for each sector plus an External Communicator and one or more Supervisors. To make the PSVTS results comparable to Sector Watchstander results in other VTS's, the three positions directly concerned with traffic (Primary Communicator, Plotter, and Radar Operator) were combined and their average time allocations computed for a "Traffic Team." These results (see Table 5-1) show that at PSVTS, for the functional equivalent of a Sector Watchstander, 13 percent of the time is devoted to communication with vessels, 5 percent to other communications, 41 percent to monitoring, 24 percent to plotting, and 17 percent to miscellaneous activities.

## 5.2 Communications

Communication between the VTS and the vessels in the system largely determines the effectiveness of the operation. The degree to which PSVTS fulfills its mission depends on the accuracy and timeliness of advisory information passed to the vessels. In turn, the basis for that advisory is the reported data from the vessels, and the effectiveness of the advisory is limited by the accuracy and timeliness of this received information. It is understandable, then, that communication is given considerable emphasis in this study.

To state that the Primary Communicator spends 40 percent of his time in communications with vessels in the system is to understate the overall situation. As pointed out in the interviews (4.6.1, B17*) and as judged by the TSC team, this position puts more stress on the individual watchstander than any other. The Primary Communicator is always aware that he must be alert to incoming calls and potential emergency situations and, therefore, must be knowledgable about the current traffic situation. He must be able to handle two or more vessels almost simultaneously, knowing that not all of the vessels operating in the VTS area are willing participants. So, to that 40 percent

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*A letter reference indicates an appendix to the report. Thus, B17 refers to Paragraph 17 in Appendix B.

radio time, enough closely related activity is added to justify claiming that about 98 percent of his time is occupied with a combination of communication and closely related support activities.

A close look at communications reveals three categories that warrent special attention: communication and traffic load, communication as a function of transmission site, and the actual nature of the vessel advisories.

### 5.2.1 Communication and Traffic Load

It is to be expected that as the *number* of vessels participating in the VTS increases, the amount of communications activity would also increase. Figures 5-1 and 5-2 show the relationship between the number of vessels in the system and the number of communications (Fig 5-1) and the total amount of time spent in communication (Fig 5-2) for each of the sample hours. The correlation[5] in the former case is .88 and in the latter,

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[5]A correlation coefficient is an index of the degree to which two sets of measures vary together; 1.00 indicates a perfect relationship, 0.00 indicates no relationship, and a negative value means that one measure increases as the other decreases. Statistical significance is based on an estimate of the likelihood that the value obtained was due to chance alone rather

(Continued)

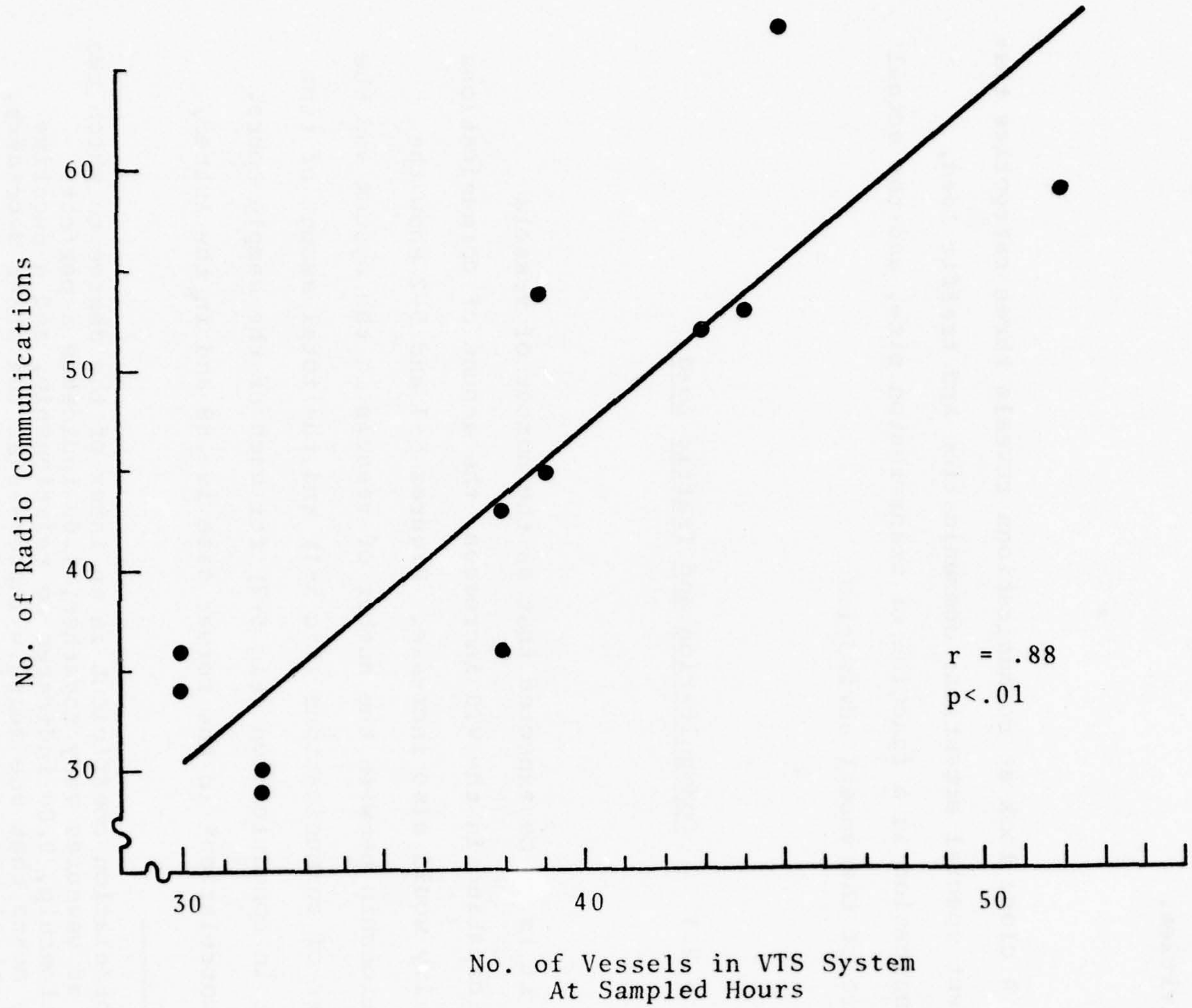


FIGURE 5-1. RELATIONSHIP BETWEEN THE NUMBER OF COMMUNICATIONS AND THE NUMBER OF VESSELS IN THE VTS SYSTEM

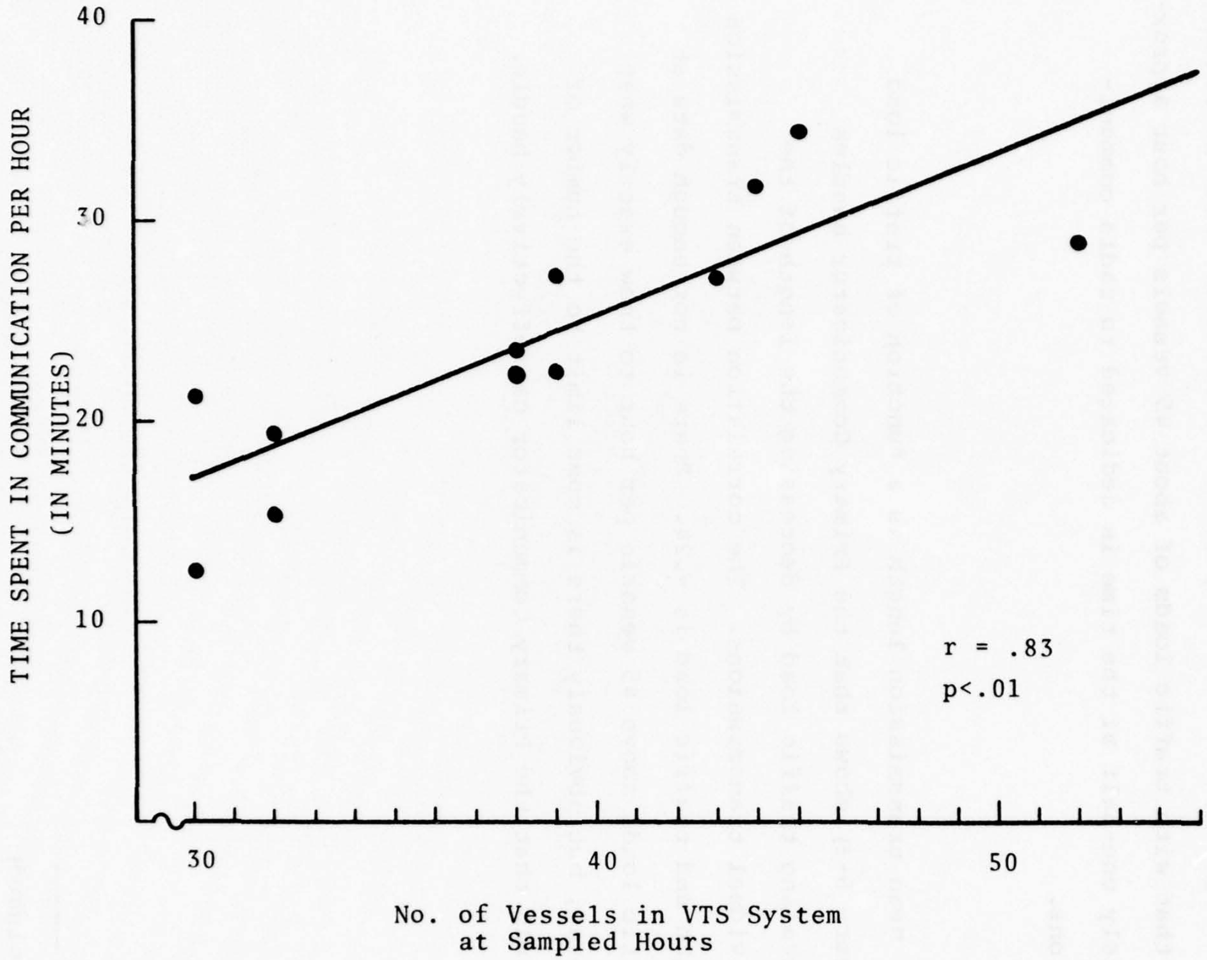


FIGURE 5-2. RELATIONSHIP BETWEEN TIME SPENT IN COMMUNICATIONS AND THE NUMBER OF VESSELS IN THE VTS SYSTEM

.83. In the interviews, the watchstanders indicated that they feel that as Primary Communicator they can handle up to about 45 vessels per hour before they become overloaded. Note in Figure 5-2 that with traffic loads of about 45 vessels per hour approximately one-half of the time is dedicated to radio communications.

Mean transmission length as a function of traffic load (Figure 5-3) shows that the Primary Communicator handles increasing traffic load by decreasing the length of the individual transmissions. The correlation between transmission length and traffic load is -.24. There is not enough data at traffic loads above 45 vessels per hour to know exactly what happens, but obviously there is some limit to the number of vessels that the Primary Communicator can effectively handle.

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(Continued)
than to a true relationship. It is customary to accept as significant only values that would have less than one chance in twenty ($p<0.05$) of occurring by random variation.

### 5.2.2 Transmission Sites

An analysis of the relative amounts of communication time per transmission site is presented in Table 5-2. When the total communication time per site is divided by the respective number of transactions, the mean transaction time per site results. The significant point here is that the mean transaction time for Bakohus Peak is up to 70 percent larger than for any of the others. The major reason for this is the high proportion of deep-draft vessels entering or leaving the system at the ocean boundary. Although this is a voluntary section of the PSVTS area, most of the vessels do participate (see Table 4-1). These incoming vessels often have foreign masters at the helm who have trouble speaking and understanding English, resulting in delays in the Primary Communicator's obtaining all the pertinent information on the vessels. But even without a language problem, extra time is required to obtain pertinent data on the status of the vessel regarding the condition of onboard radar, communication equipment, and the presence of any mechanical difficulties or oil leakage.

When the Primary Communicator is talking with an entering vessel over the Bahokus Peak site it is difficult for him to interrupt this interaction to deal with other vessels which may be calling from somewhere else in the system. So, to the degree

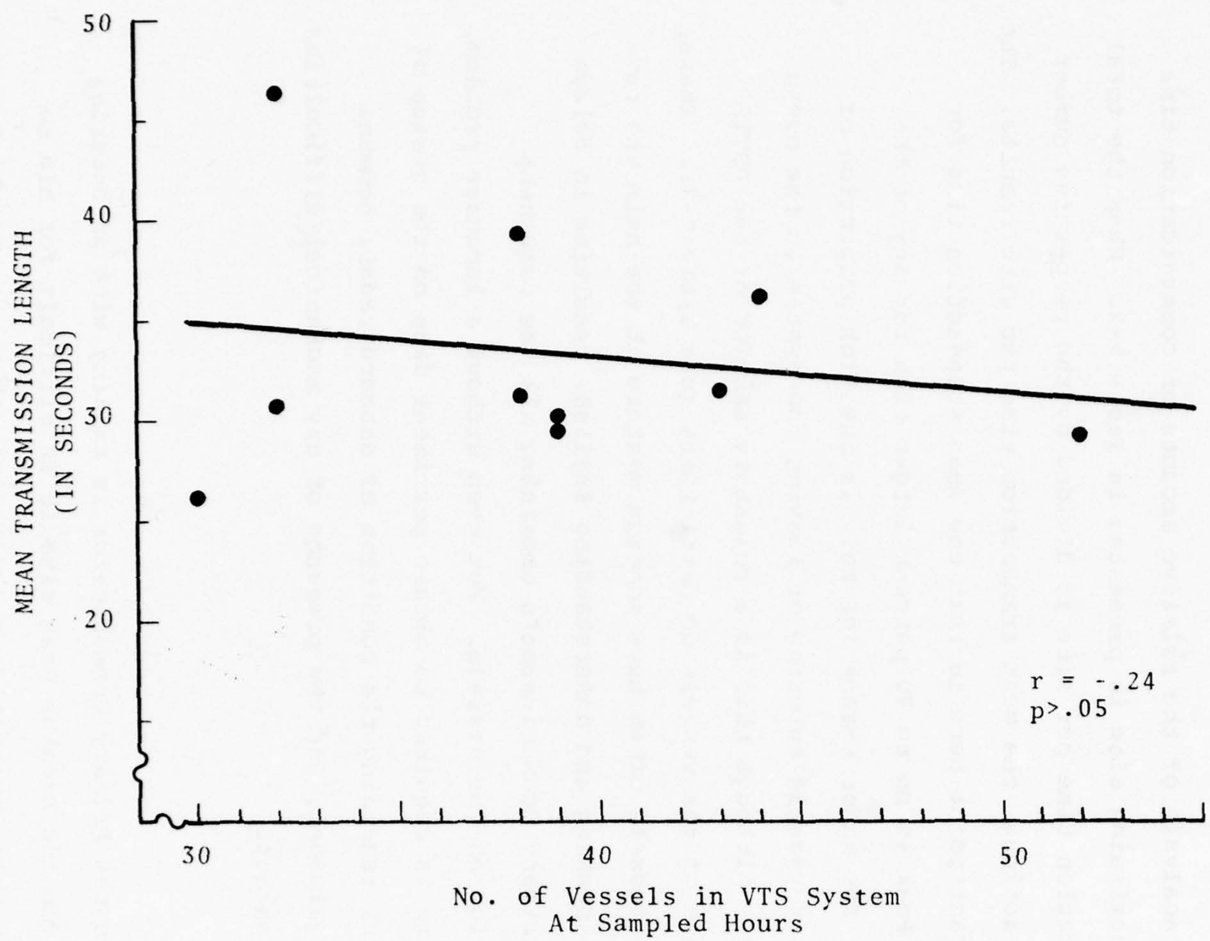


FIGURE 5-3. RELATIONSHIP BETWEEN MEAN TRANSMISSION LENGTH AND THE NUMBER OF VESSELS IN THE VTS SYSTEM

TABLE 5-2. COMMUNICATION DATA AS A FUNCTION OF TRANSMISSION SITE

| | Bahokus Peak | Mt. Constitution | Gold Mountain | West Point |
|---|---|---|---|---|
| Total Time in Communication (in seconds) | 2,246 | 5,010 | 8,292 | 1,728 |
| Number of Radio transactions | 44 | 153 | 281 | 55 |
| Mean Time Per Transaction (in seconds) | 51.05 | 32.75 | 29.51 | 31.42 |

that traffic increases in the Strait of Juan de Fuca, the Primary Communicator will have a much more difficult job. Particularly when participation becomes mandatory in the Strait of Juan de Fuca, sectorization would help to minimize radio channel overloading and provide more immediate service to other vessels in the system.

### 5.2.3 Advisories

It is difficult to evaluate the complete effect of the services provided by the PSVTS on the users of the system. An indication of some of the complaints is evident in the discussion with the pilots' association (Appendix D). But to many there is the impression that information received from "Seattle Traffic" is an official statement of the U.S. government. Under these conditions it is imperative that information contained in an advisory given to a vessel be accurate. But even apart from this reliance on the official word, only to the degree that PSVTS does provide accurate information to the pilots and masters will the credibility of the VTS be enhanced. Therefore, all reasonable effort should be made toward reducing any error in the plotting and reporting systems.

Another area deserving study and possible revision concerns the content of the advisories themselves. A typical transaction between a vessel and the VTS includes an initial call, acknowledgment, message and response, followed by an advisory about the traffic condition the vessel should encounter over the next half hour. The pilots interviewed complained that many of the advisories given by the VTS are unnecessary. They felt that responding to a VTS call took a pilot away from other more important tasks simply to respond to a message which was not needed. They also felt that the advisories were too long. That is, sometimes the reported traffic for the next half hour might include 10 or more vessels and there would be no way the pilot could remember all these meetings and overtakings. In conversations with TSC personnel on this topic, some of the watchstanders agreed with the pilots to a degree. Also, they said that when the traffic is heavy the problem is often aggravated by a VTS practice of giving an advisory for the next hour to conserve radio time by reducing the number of advisories.

At this time no specific recommendations seem proper concerning changes in the nature of advisories, but it is suggested that PSVTS look closely at their current procedures. For example, when the visibility is good, how important is it to notify vessels of other approaching vessels within the TSS areas? How far in advance should traffic be described?

There is not enough information available to deal adequately with these problems, but it is felt that sectorization could help to alleviate the pressure put on the Primary Communicator.

## 5.3 Plotting

The Plotter spends almost as much time in maintaining the board as the Primary Communicator does in radio transactions with the vessels. However, he is not under the same stress and has more time to perform his specific duties to keep the board current. Since the Primary Communicator bases his advisories on the information provided by the board, the correct placement of the models is very important.

There are two major ways in which the position of the model can be in error: from the initial placement on the board and from improper updating. The initial placement accuracy can be improved simply be requiring the Plotter to be more precise, but errors in updating are more complicated.

One source of error in updating results from careless repositioning by a watchstander. Another source is erroneous information on SOA on the tiles. Although vessels are required to report any change in speed greater than plus or minus one knot, in practice this is often not done, resulting in improper dead-reckoning updates. A third kind of updating error results when the Plotter applies a routine 15-minute advance to a vessel that has been updated within the last 15 minutes.

Measuring position discrepancies was not part of the initial plan of this study but incidental data on discrepancies were recorded. Whenever the Plotter adjusted (corrected) the position of a model on the board, an observer noted the absolute amount of change in terms of model lengths. (Each model had a scale length equivalent to 2 1/4 miles). Over 11 hours of observation, 72 model adjustments were recorded, ranging from 0 (no change) to 3 boat lengths (6.75 miles). The mean adjustment was the equivalent of 1.03 miles. These statistics are only descriptive and all that can be said is that for those models that were recognized as being out of position on the board the average deviation represented about 1 mile off course. Nothing can be said about the proportion of vessels that were off course or what the source of the error was.

An important consideration in the analysis of position discrepancy is how important these discrepancies really are. In other words, how much discrepancy can be tolerated before serious errors occur in transmitted advisories? Regardless of the answer to this question, it is obvious that the board should represent the vessel traffic in the VTS area as accurately and as efficiently as possible. This could be accomplished with the addition of more precise radar at more sites and with regularly scheduled radar updates. These new radars would also help solve the problem of reported vessel speed since the pilots would know that PSVTS had the radar capability to closely monitor both speed and position.

Still another problem with the plotting board is the confusion which could occur as the number of vessels become concentrated at certain parts in the system. Since each model occupies the equivalent area of about one-half square mile on the board, as more vessels converge positioning errors will necessarily occur. This is a problem that the present system cannot overcome; therefore the watchstander must monitor the traffic in a congested area closely until the congestion clears up.

In summary, given the present use of the plotting board at PSVTS, the major recommendations resulting from this study would be to increase the radar coverage (presently in the planning state) and begin each scheduled board update with the more precise radar update.

## 5.4 Operational Factors

### 5.4.1 Sectorization

There is a second communicator's console in the VTC located near the Plotter's position. In the past, attempts have been made to reduce the Primary Communicator's workload when the traffic load was heavy by dividing the system into two sectors, giving the Plotter the Primary Communicator function for the second sector and having the Radar Operator maintain the plot as well as monitor the radar scopes. These efforts were largely unsuccessful, because the two Communicators' radio messages interfered with one-another.

Sectorization would be a distinct and immediate possibility, however, if one or more radio channels could be added to Channel 14 as VTS channels. This is not an unreasonable consideration, since the New Orleans VTS has Channels 11, 12 and 14 reserved for VTS traffic.

Although average traffic loads (about 38 vessels) do not overload the Primary Communicator (4.6.1), overload was estimated to start at about 45 vessels (B25). Thus an occasional buildup of traffic can temporarily overload the Primary Communicator, and a moderate increase in the average system traffic would keep him continually overloaded and require queuing of traffic service requests. Sectorization (even two sectors) would not only reduce the frequency of Communicator overload and user waiting, but would also reduce the area and number of vessels to be monitored by the Communicator, thus reducing the chances of overlooking a critical traffic incident or misreading a vessel's position.

### 5.4.2 Radar

Upgrading present radar equipment and adding radar sites were primary concerns of the watchstanders who were interviewed (4.6.1, B19, B29). Since efforts are presently under way to meet these objectives, they need not be further elaborated here.

Staffing the radar position raises problems of fatigue and vigilance. The equipment is noisey, and the need to work at a low level of illumination is visually fatiguing. The Radar Operator must detect the problems he is there to resolve; the system does not call them to his attention. Present requirements for plotting radar targets and adjusting radar equipment occupy only a little over a third of his time -- and some of that may be "busy work" (4.4.6). A procedural change adopted during the observation period relieves Watch Chiefs from radar duty; so the other watchstanders will spend even more time on the scopes. There is considerable risk, then, that the Radar Operator's attention may be distracted from the job.

### 5.4.3 Procedures

The PSVTS Traffic Center Manual specifies some procedures in considerable detail but is not specific about all procedures. Consequently, each Watch Supervisor has adopted his own preferences for procedures, particularly with regard to updating the plot. Since watch personnel are regularly regrouped rather than being assigned as teams with the same supervisors (2.4.4), there is a degree of uncertainty on any watch as to exactly how things should be done. This problem was recognized and discussed at a supervisors' meeting during the observation period.

There was some variability in plot update procedures during the TSC observations. The basic 15-minute board update was conducted as specified, but there were fewer formal radar updates than dead-reckoning updates. Also, in some instances, the radar update followed the dead-reckoning update. Since the radar information on position is up-to-the-minute and is more precise than dead-reckoning positions, it might be desirable to require a formal board update every 15 minutes in the following sequence: (a) an updated location of every vessel model for which there is a radar position, then (b) a dead-reckoning update of those vessels not covered by radar. The radar update should require the Radar Operator to call to the Plotter the name and location of every vessel on his scopes, and each position should be acknowledged by the Plotter. This procedure would not only avoid having models in erroneously dead-reckoned positions when radar positions are available, but would help maintain alertness in the Radar Operator by providing him with a periodic job-related task.

Another plotting procedure that should be studied, standardized and enforced is the 15-minute updating of models whose positions have been determined (by entry, check point, radar, etc.) since the last general update. Advancing these models to 15-minute dead-reckoned positions adds unnecessary error to their positions.

In general, it would be advisable for all supervisors to review all procedures, agree on a standard set, state these clearly in a revised manual, and enforce them.

### 5.4.4 Workspace

Illumination. The most striking characteristic of the operations room at the Puget Sound VTS is its dim level of illumination, maintained to minimize interference with the radar displays. A more subtle feature is the variability in illumination. Overhead fluorescent and spot lights brighten work stations but create glare spots on shiny surfaces. The plotting board is both front-and back-illuminated. During daylight hours, the windows are covered with heavy drapes. None of the interviewees (Appendix B) complained about illumination, yet the highest somatic stress rating (Appendix C) was "Aching or Burning Eyes." Continual readaptation to different light levels may account for some of this visual stress. Other factors may be the necessity to read fine detail (model data and radar returns) at low light levels and to change accommodation for different distances in monitoring the plotting table.

Noise. There were complaints in general conversation and in the interviews (B32) about the noise level, mainly from the air conditioner and the radar consoles. Sound shielding has reduced radar noise, but it is a tiring factor at the Radar Operator's position and may help account for the relatively low level of communication between that position and the Plotter (Table 4-7).

Arrangement. The interviews yielded only a few suggestions for rearrangement of equipment, primarily for elevating the Primary Communicator, making the radar more accessible to him, and consolidating the External Communicator's position.

Both the Primary Communicator and the Radar Operator have a seated eye level (on the average) of only 15-16 inches above the plotting table. Being close to the table, the Primary Communicator can look down onto the nearer portions of the table, raising his position would improve his view of more distant areas.

The Radar Operator gets a grazing look at the table top. The width of the table top subtends an angle of only 2.25 degrees at the seated Radar Operator's eyes. He frequently stands up and moves as close to the table as his radar consoles permit, expanding the visual angle of the table top to about 5 degrees.

Elevating the Radar Operator's position onto a one-foot-high platform would increase the angle to 4 degrees seated, 7 degrees standing. A better advantage can be gained by moving the Radar Operator closer to the plotting table. A five-foot move toward the table at floor level would yield 6 degrees seated, 10 degrees standing, while elevating the position one foot would give 10 degrees seated, 13.5 degrees standing. Additional advantages would be realized by elevating the Radar Operator's position and moving it closer to the plotting table: the radar consoles could be arranged so that the Plotter could see the scopes; the radar consoles (and their noise) would be farther from the Plotter and Primary Communicator, and the Radar Operator would be closer to the other watchstanders.

Consolidation of the External Communicator's position mainly involves bringing the teletypes closer to the basic position. As it is now, the External Communicator must cross the room each time this equipment requires attention. Sound-shielding would be required because of teletype noise.

### 5.4.5 Options for System Improvement

There are numerous ways that the PSVTS operation might be improved. Some improvements can be implemented almost immediately. Other improvements are contingent on basic changes in the system, three of which will be discussed: additional communications channel (s), improved radar, and computer assistance.

Immediate Improvements. Operating procedures can be reviewed and tightened up immediately. A formal radar update of the plot preceding each 15-minute dead-reckoning update is strongly recommended. All procedures should be standardized so that any watchstander need know but one way of doing each task, regardless of watch section assignment.

Further study of illumination is desirable to eliminate glare spots and, if feasible, to shield the radar scopes enough to permit a higher level of room illumination. Replacing the drapes with transparent tinted plastic curtains would raise the light level to some degree and overcome complaints about being closed in during the day. Noise reduction should also be considered, particularly additional sound-shielding of the radar and teletype equipment.

Rearrangement of present equipment also merits immediate consideration. Items to be considered include: elevating the Primary Communicator, lowering his communications console and placing it in front of him, elevating the Radar Operator, moving his position closer to the plotting table, rearranging the radar equipment so that the scopes can be seen by the Plotter, and moving the teletype equipment to the External Communicator's position.

Improvements with More Communications Channels. If even one additional channel were reserved for VTS use, the present operation could be sectorized. Equipment is already on hand for a second Communicator's position. Each Communicator would have less traffic to handle, reducing the risks of overload. An additional person would be desirable for each watch section; however, if this were not possible, the Plotter or the External Communicator could monitor the radar. An alternative development that might permit sectorization would be to relocate radio transmitter sites to reduce area overlap.

Improvements with Improved Radar. When the proposed new radar sites and equipment are operational, it may be possible to locate radar repeaters at Sector Watchstander positions, eliminating the Radar Operator function and position. Should equipment permit each sector to be covered on a single scope, then the

radar and communications equipment could be consolidated in a Sector Watchstander's console, and tracking could be performed on the radar. At this stage of evolution, serious study could be made of elimination of the Plotter function and the plotting table.

<u>Improvements with Computer Assistance</u>. Introduction of computer assistance, such as is operational now at Houston-Galveston and New Orleans, would be the final step in the evolution of PSVTS to a fully sectorized operation. With the computer performing frequent position updates and predicting future traffic patterns, the Plotter and plotting table could definitely be eliminated, and an integrated, standard Sector Watchstander position would be feasible. This stage of development is in the indefinite future for PSVTS, but each change at the Center should be undertaken with a smooth progression of operations to this end in mind.

## 5.5 Personnel Factors

### 5.5.1 Staffing

At the time of the data collection for this study, PSVTS was well staffed. However, past experience at PSVTS as well as experience at other VTS's shows that current USCG staffing procedures permit staffing crises to occur periodically. These crises occur when a number of personnel transfers take place at about the same time. Because (a) replacements generally do not arrive before the transferees depart the VTS and (b) it takes 6 to 8 weeks to prepare a replacement to stand watches, the VTS must run short-handed during the training period, with consequent extra hours of work, fatigue, lowered morale and general lowered performance levels. This situation is occasionally aggravated by the assignment of a person who, for any of a number of reasons, can not qualify as a watchstander. The time lost during training and transfer of such an untrainable can be upwards of a year -- a serious impediment to maintaining a 24-hour service with a limited number of people. The USCG is presently examining selection and placement procedures to alleviate these conditions.

### 5.5.2 Career Considerations

The interviews (4.6.1, B7) revealed a dissatisfaction with VTS duty among senior enlisted personnel. Because all watchstanders, regardless of grade, perform the same duties, there was a feeling among CPO's that they were not being utilized to their capacity --- that they were not doing what they were trained for. They felt that this definitely puts them at a disadvantage in their next assignment (they're out of practice in their special skills), and therefore they do not regard a VTS assignment as a desirable career step.

While the TSC team was at PSVTS, the SOP was changed to relieve the Watch Chief from staffing the Radar Operator position, because the remoteness of the position was declared to affect the Chief's readiness to take charge of the VTS in the absence of the Watch Officer. It may be possible further to redefine procedures so that senior personnel can assume additional responsibility and authority more commensurate with their ratings.

## 5.6 Recommendations

Analysis of all of the data collected at PSVTS has revealed several areas that appear to be amenable to improvements. The feasibility and desirability of implementing these changes can not be determined from this study; however, we do recommend that consideration be given to these recommendations and that their feasibility be given study. (Note: At the time of publication, PSVTS had taken positive action on recommendations a and d, and the District had established a study group to investigate and act on several others.)

### 5.6.1 Immediate Recommendations

a. Adopt as standard procedure a complete radar update before each 15-minute dead-reckoning update. (5.4.2, 5.4.4)[6]

b. Review and standardize all operating procedures. (5.4.3)

c. Study ways to reduce the number of advisories

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[6]Numbers in parentheses refer to relevant sections of this report.

and to shorten their contents. (5.2.3)

d. Consolidate the Primary Communicator's communications equipment into a smaller and more conveniently located position. (5.4.5)

e. Elevate the Primary Communicator and Radar Operator Positions, if feasible. (5.4.4)

f. Move the Radar Operator closer to the Plotting table, if feasible. (5.4.4)

g. Rearrange radar equipment to make the scopes visible to the Plotter, if feasible. (5.4.4)

h. Substitute a tinted transparent plastic curtain for the window drapes. (5.4.5)

i. Continue efforts to reduce glare spots. (5.4.5)

j. Seek ways to improve light-shielding and sound-shielding of radar equipment. (5.4.5)

k. Improve sound-shielding of teletype equipment and relocate at External Communicator position. (5.4.5)

5.6.2 <u>Recommendations with Improved Communications</u>

l. Divide the Primary Communicator function into two or more Sector Watchstander Positions. (5.2, 5.4.1, 5.4.5)

m. Further consolidate the communications console. (5.4.5)

5.6.3 <u>Recommendations with Improved Radar</u>

n. Provide each Sector Watchstander with a radar display covering his area. (5.4.5)

o. Plot radar traffic at the Sector Watchstander positions; eliminate the Radar Operator position. (5.4.5)

p. Design a consolidated radar-communications console for the Sector Watchstander. (5.4.5)

5.6.4 Recommendations with Computer Assistance

q. Use the computer for tracking and plotting; eliminate the Plotter position and plotting table. (5.4.5)

r. Use the computer to predict and display future traffic situations. (5.4.5)

s. Integrate the radar data into the computer for automatic radar tracking. (5.4.5)

t. Design an integrated computer radar-communications Sector Watchstander console. (5.4.5)

5.6.5 Personnel Recommendations

u. Redefine VTS duties to give more responsibility and authority to CPO's.

v. Continue efforts to develop selection criteria for VTS duty.

w. Modify assignment practices to permit overlap

of incoming and outgoing personnel for a training period.

APPENDIX A.

EVENT SEQUENCE, ROUTINE PASSAGE

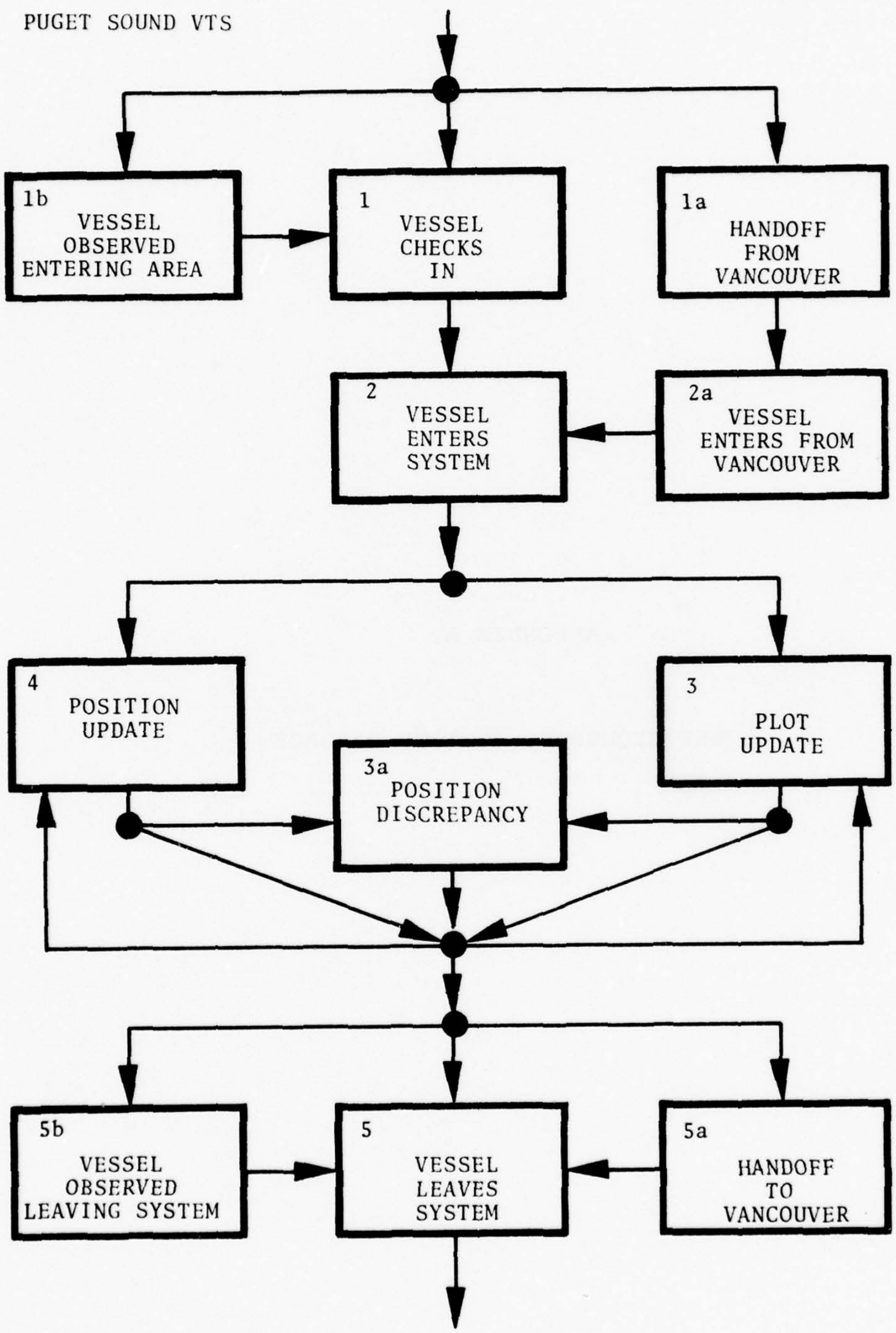



FIGURE A-1. EVENT SEQUENCE-ROUTINE PASSAGE

○ Information received by an operator or a system component

□ Operator action

◁ Transmission of information or action

◇ Operator decision

⧈ Automatic action

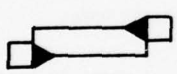
◎ Automatic receipt of information

◀ Automatic transmission of information/data

▽ Manual storage, filing of information

⧨ Automatic data storage

 A communications loop between two operators, talk without aids

 A communications loop between two operators, radio or interphone

A Aurally or Vocally

T Tactually

V Visually

● "Or gate"; follow one path only

FIGURE A-2. OPERATIONAL SEQUENCE DIAGRAM: LEGEND

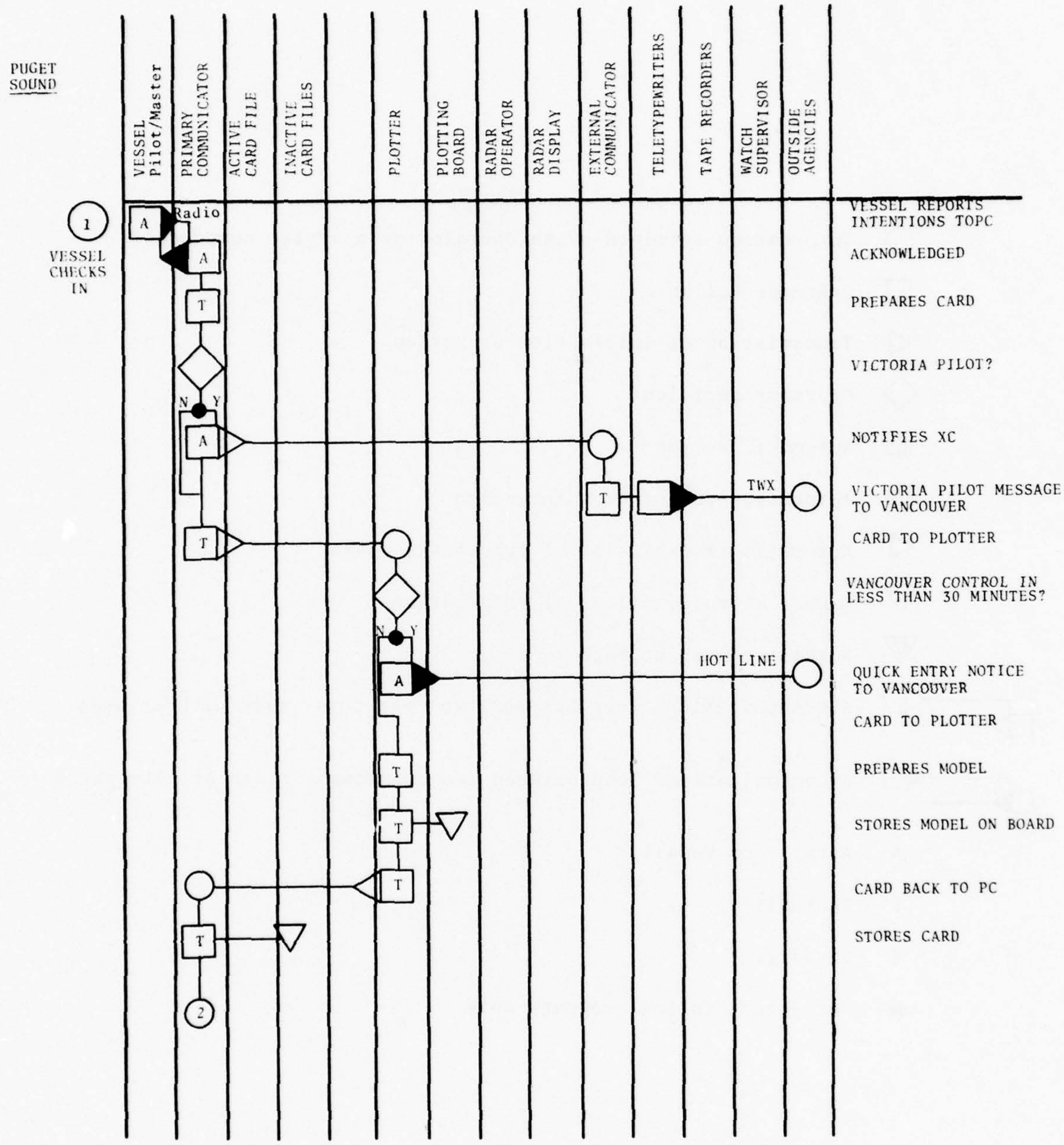



FIGURE A-3. OPERATIONAL SEQUENCE DIAGRAM: VESSEL CHECKS

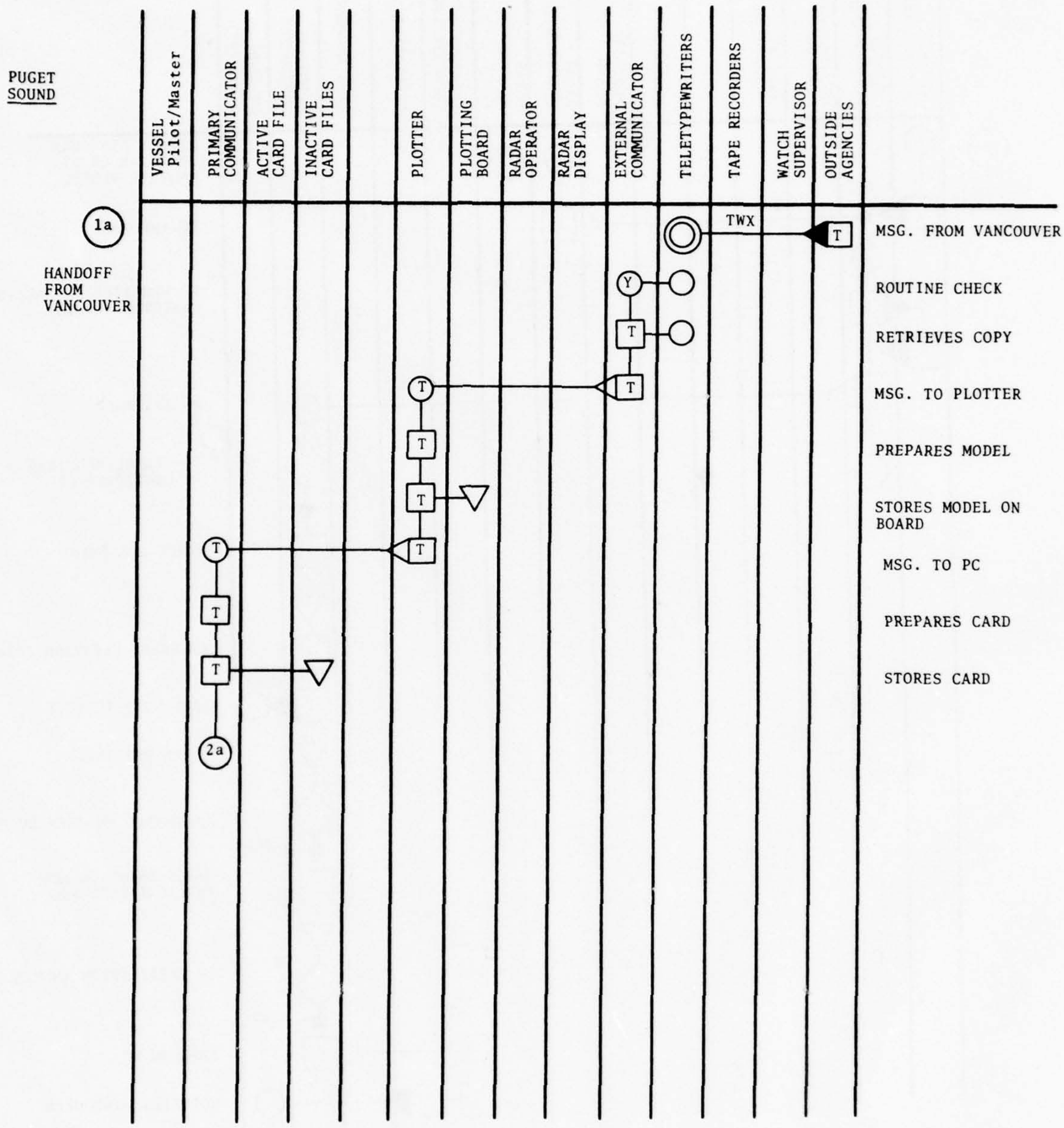



FIGURE A-4. OPERATIONAL SEQUENCE DIAGRAM: HANDOFF FROM VANCOUVER

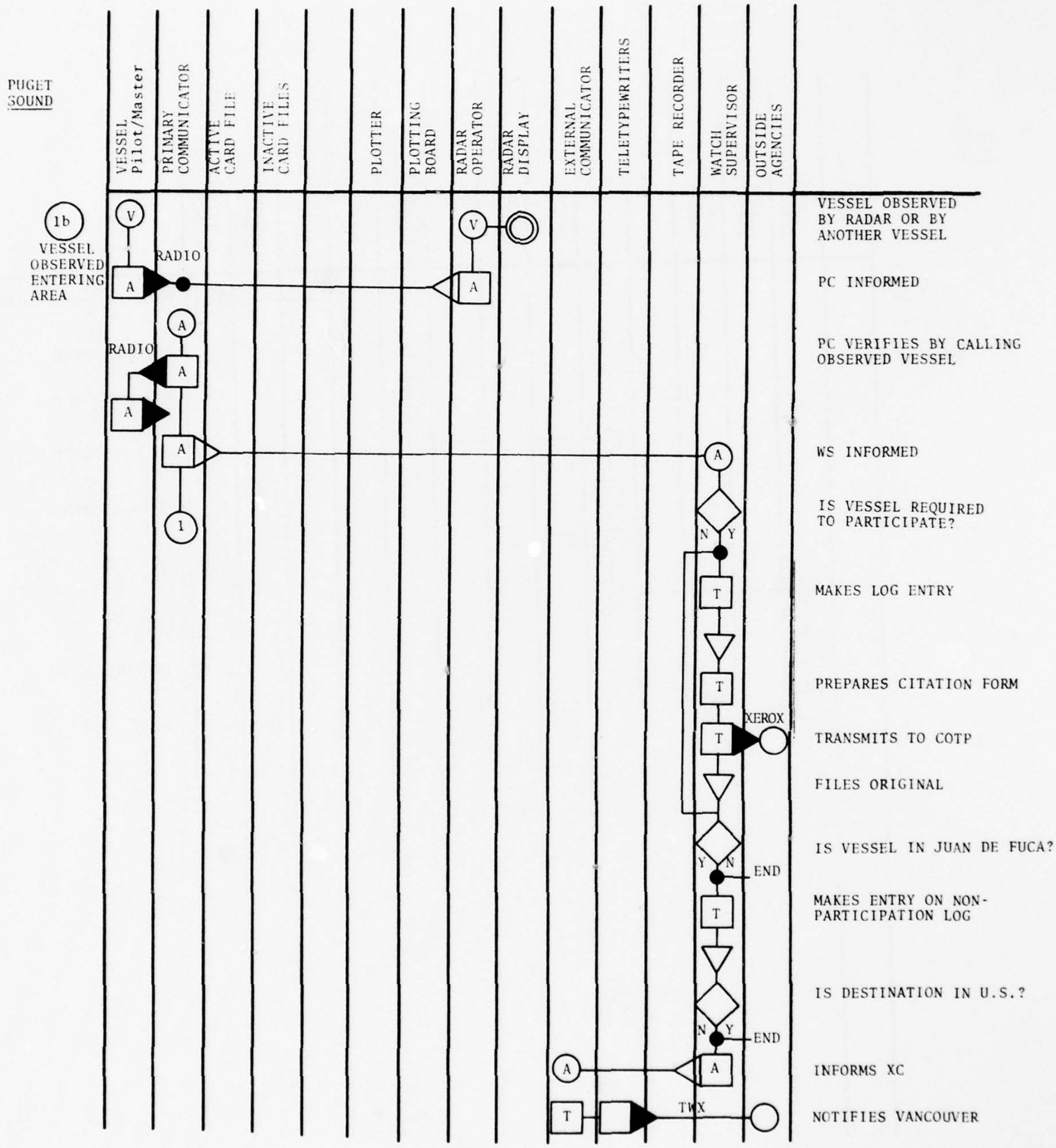



FIGURE A-5. OPERATIONAL SEQUENCE DIAGRAM: VESSEL OBSERVED ENTERING AREA

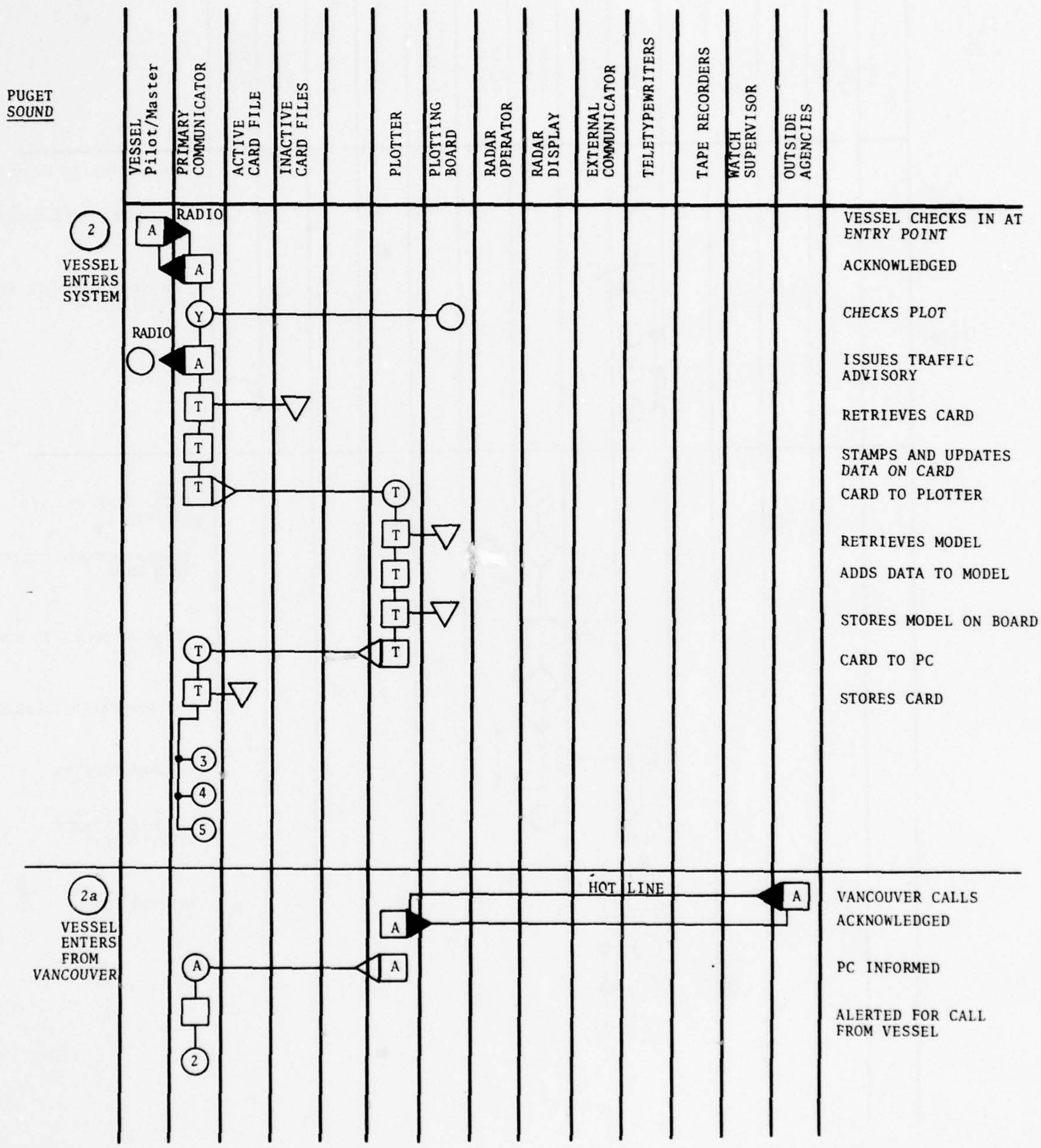



FIGURE A-6. OPERATIONAL SEQUENCE DIAGRAM: VESSEL ENTERS SYSTEM

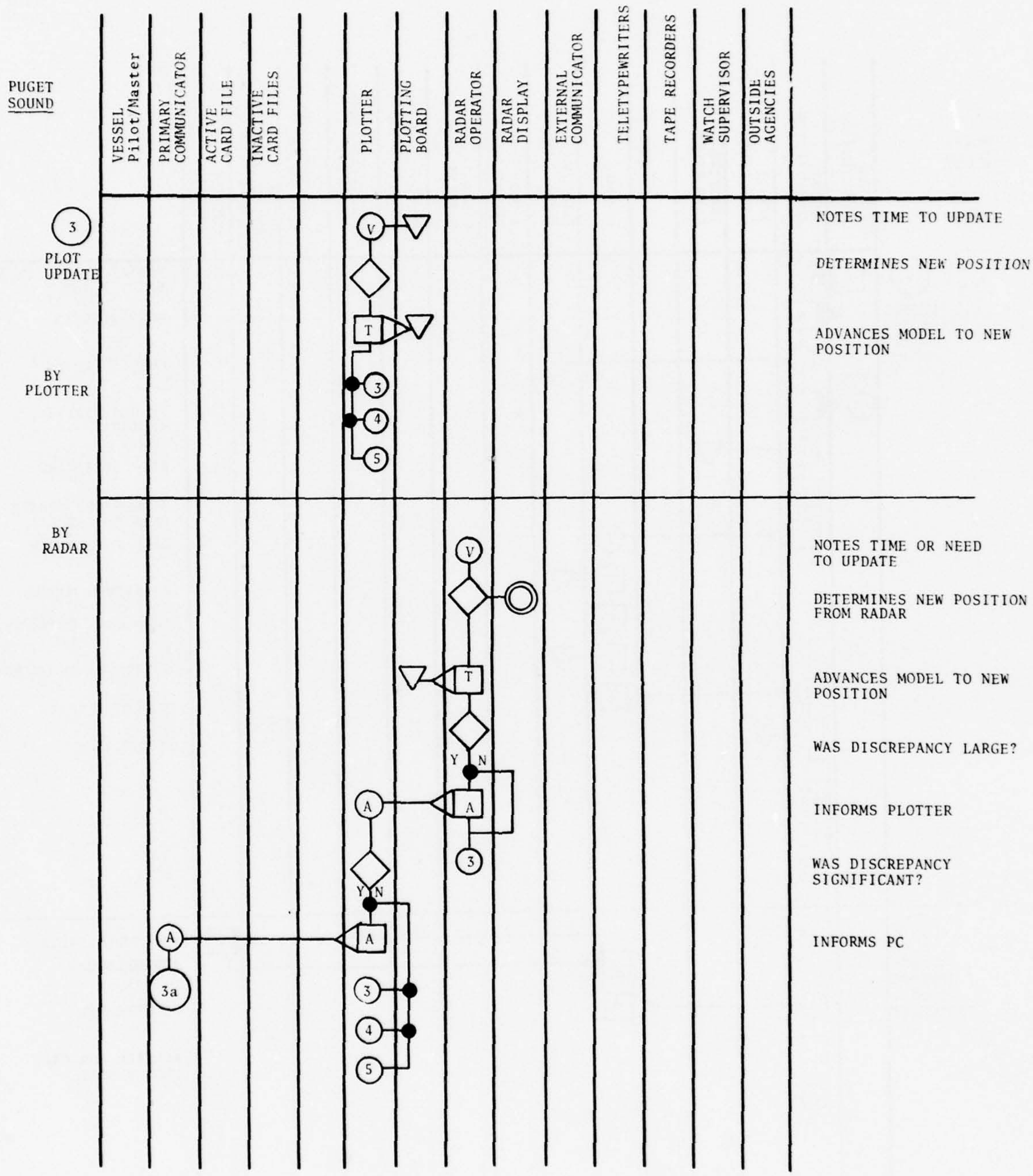



FIGURE A-7. OPERATIONAL SEQUENCE DIAGRAM: A) PLOT UPDATE BY PLOTTER B) BY RADAR

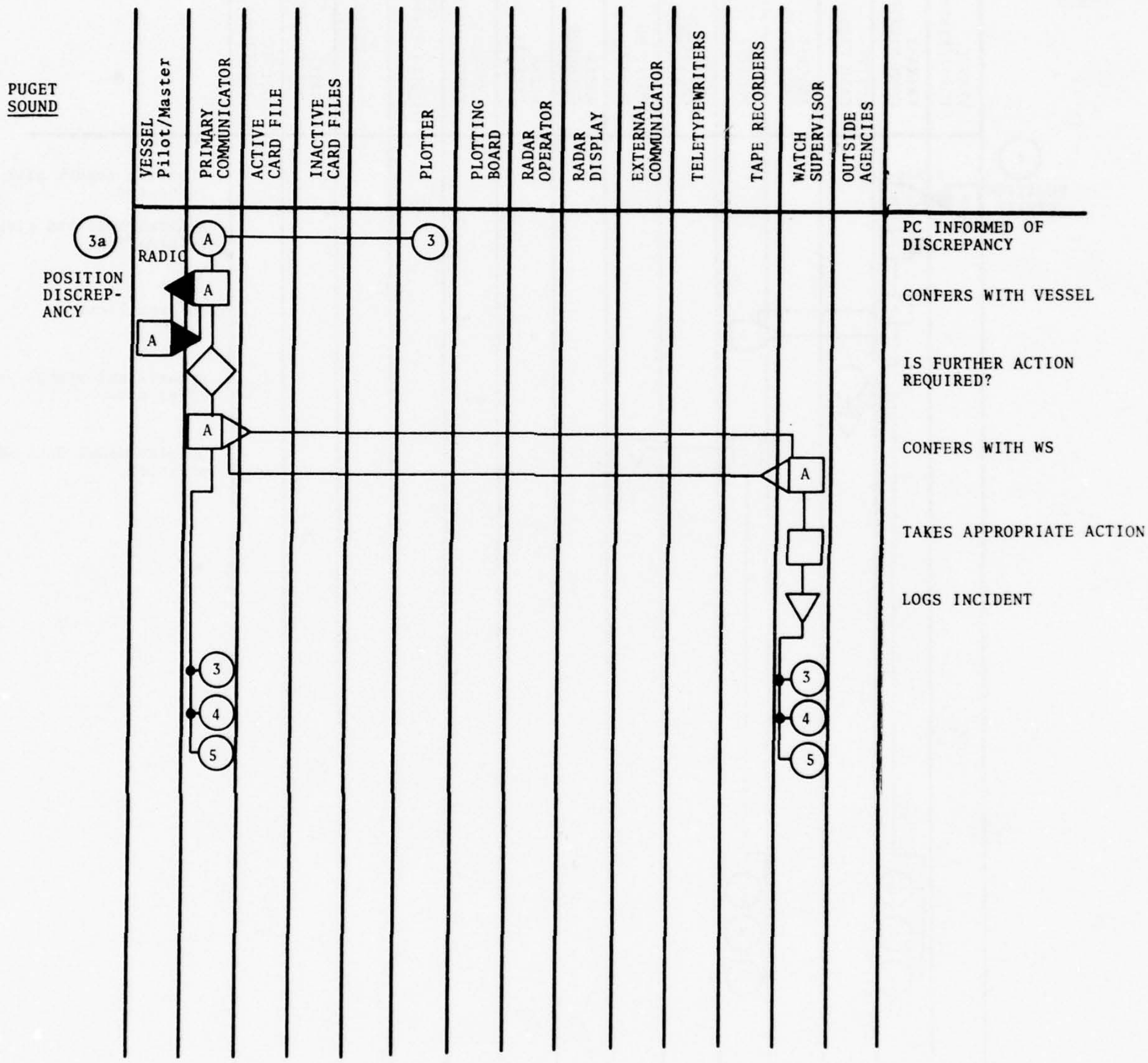



FIGURE A-8. OPERATIONAL SEQUENCE DIAGRAM: POSITION DISCREPANCY

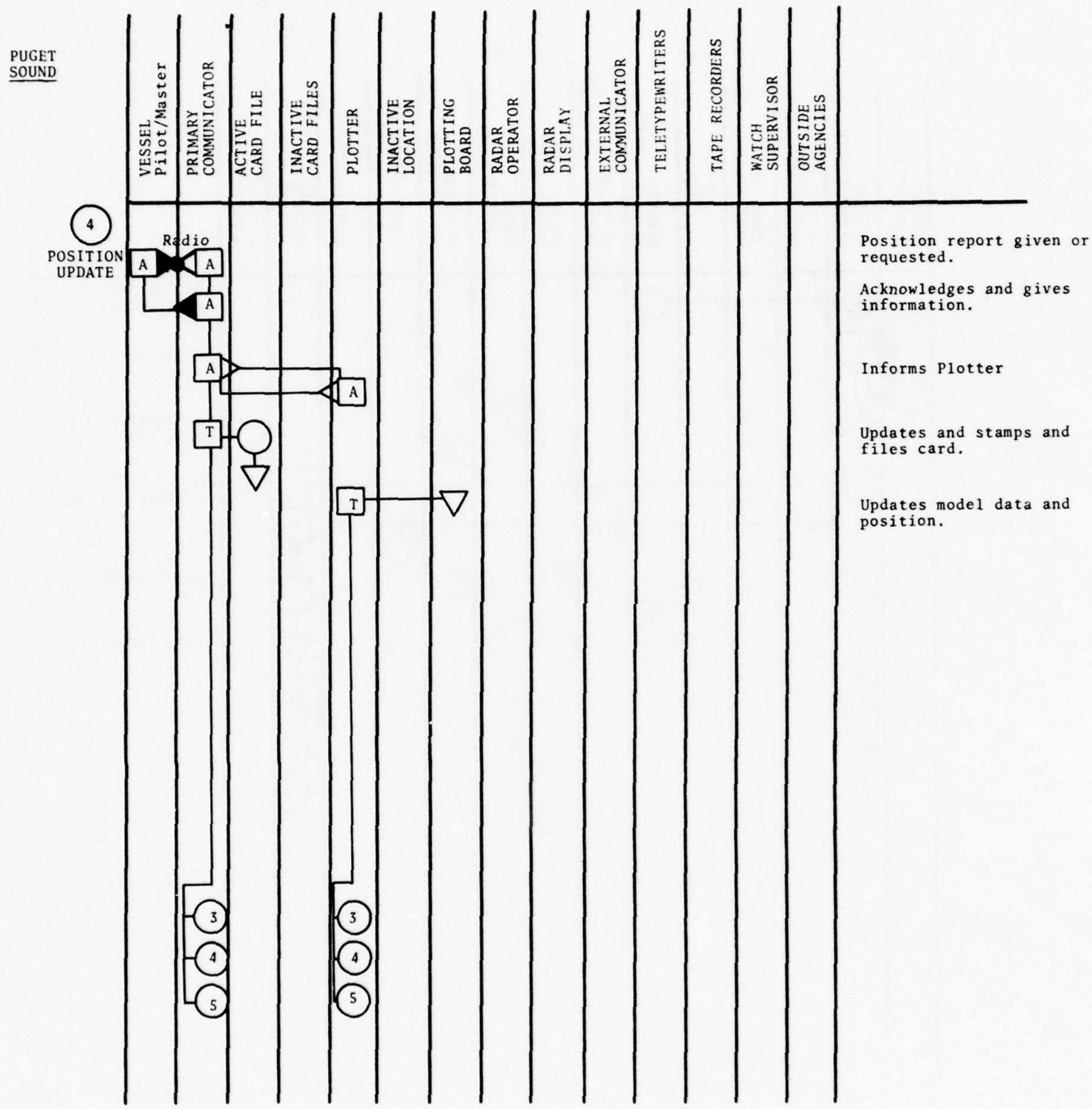



FIGURE A-9. OPERATIONAL SEQUENCE DIAGRAM: POSITION UPDATE

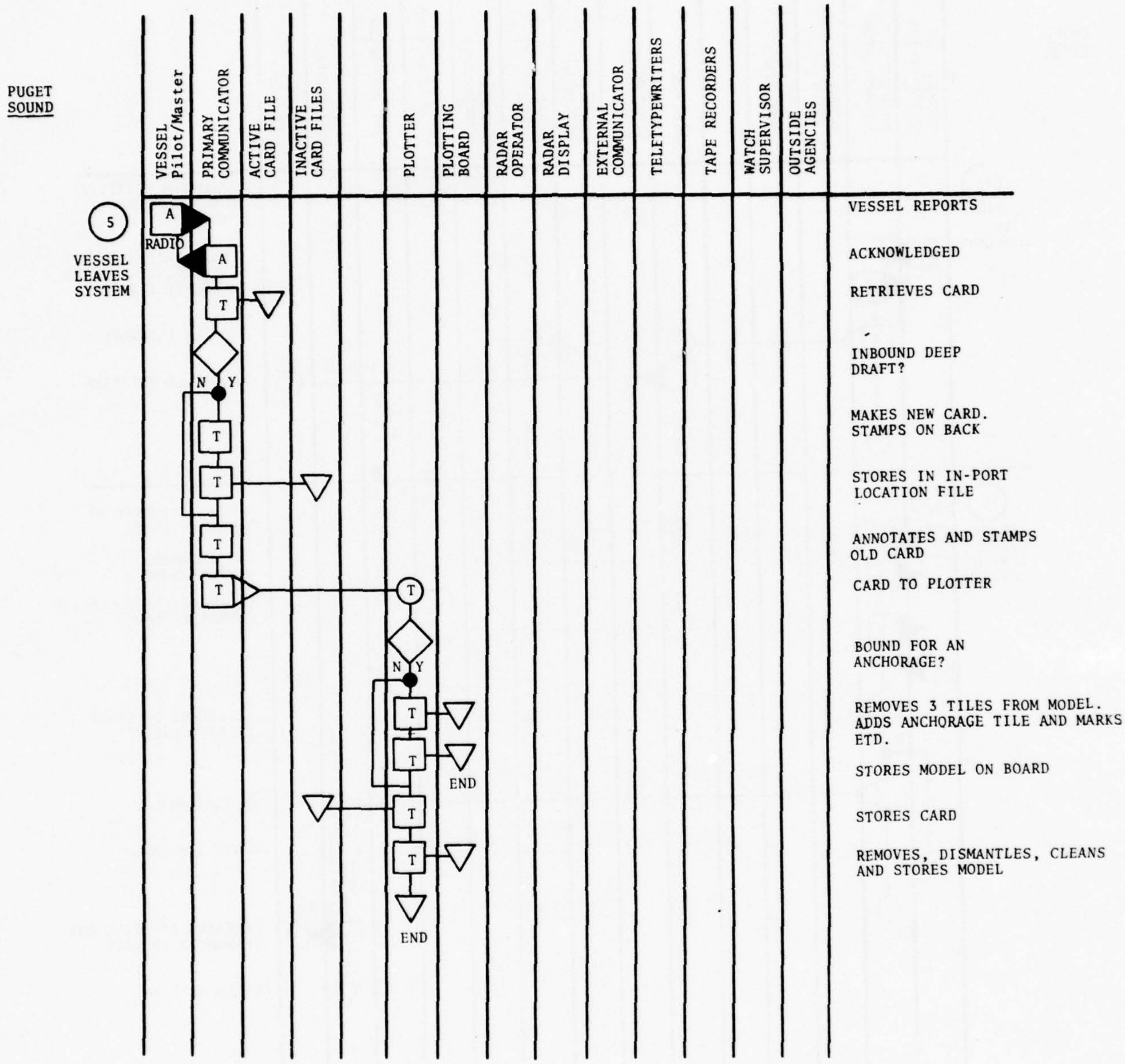



FIGURE A-10. OPERATIONAL SEQUENCE DIAGRAM: VESSEL LEAVES SYSTEM

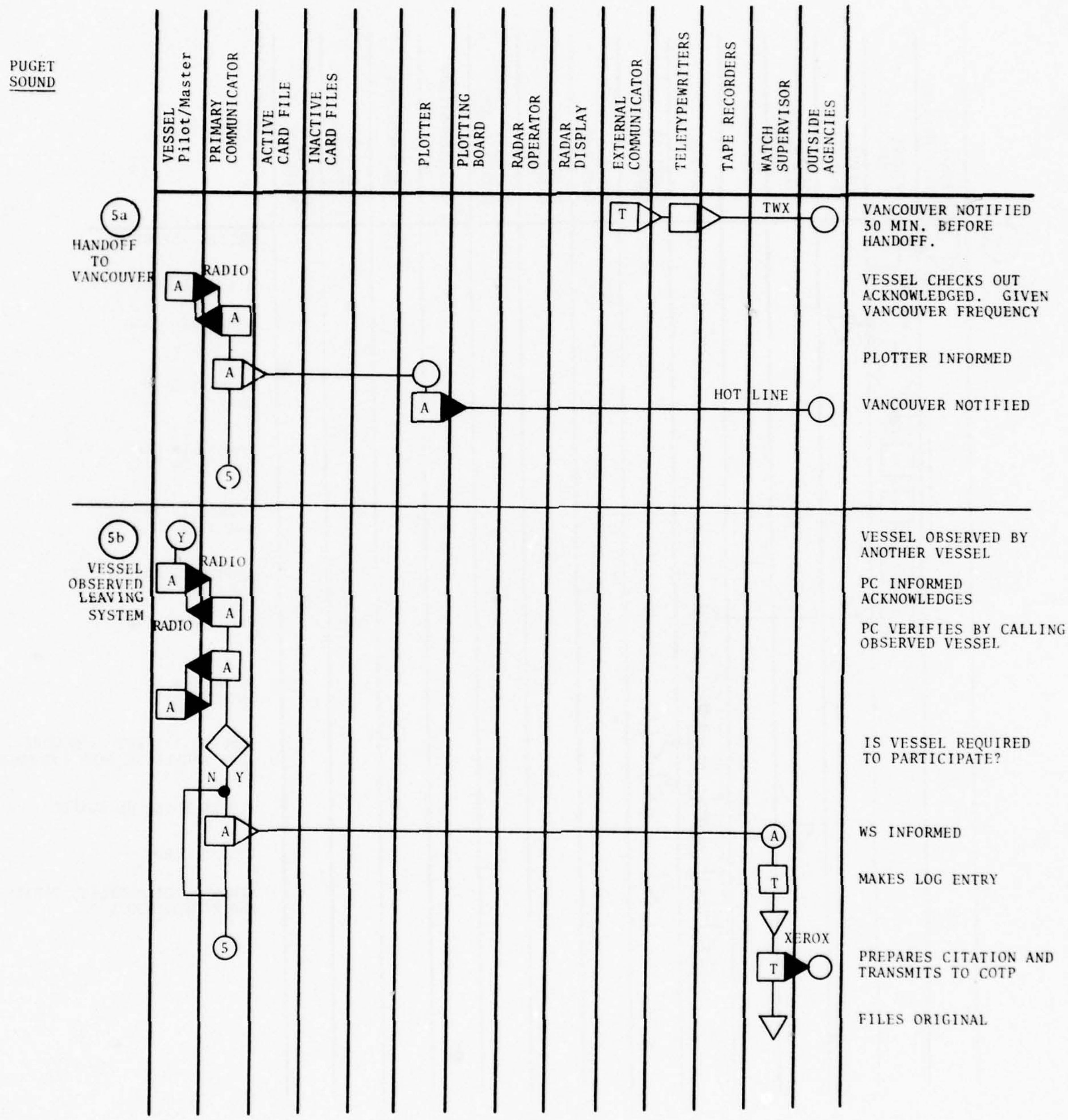



FIGURE A-11. OPERATIONAL SEQUENCE DIAGRAM: A) HANDOFF TO VANCOUVER B) VESSEL OBSERVED LEAVING SYSTEM

## APPENDIX B.

## INTERVIEWS AT PSVTS

Individual interviews were conducted with watchstanders during the same days that observations were made, generally when the interviewee was on day duty. The interviewer and interviewee were seated comfortably in a private office that was quiet and free of interruptions. The interview was conducted as a conversation. The interviewer was guided by a format in order to cover all topics, but the exact wording of questions and order of topics were varied to allow spontaneity in the interviewee's responses.

The interviewer explained the aims of the project and the interview, stressing the fact that the system, not the interviewee, was being evaluated. Then the interviewer asked, and encouraged discussion of, a series of questions. The nature of each question (not necessarily the exact wording used with each interviewee) is given below, followed by a summary of the responses.

1. How long have you been in the U.S. Coast Guard? How long have you been at PSVTS? What were your previous assignments? Five enlisted watchstanders and one watch officer were interviewed. Their answers to these questions are tabulated in Table B-1. Although the sample is small, the responses represent an aggregate of eight years of VTS experience.

2. Do you like working at the PSVTS?

Three interviewees liked the assignment, one disliked it, and two gave neutral responses. Reasons for liking work at PSVTS included liking the kind of work being done and liking the life style of a land station. The reason for disliking the assignment was that the interviewee didn't feel that he was being utilized to his full potential.

3. Is some form of vessel traffic advisory system necessary for the Seattle Area? Five interviewees responded "Yes," one "No." The reason for positive responses was that such service is imperative in a confined area, although one interviewee felt that the PSVTS was "heavy handed" and required unnecessary data. The negative response was not entirely negative; the interviewee felt the service is "desirable" rather than "necessary".

TABLE B-1. CHARACTERISTICS OF INTERVIEWEES

| Interviewees | Years in Coast Guard | Months at PSVTS | Years of sea duty | Years USCG School | Other Experience |
|---|---|---|---|---|---|
| Officer | | | | | |
| | 18 | 8 | | | |
| Enlisted | | | | | |
| 1 | 4 | 18 | 2 | .5 | |
| 2 | 3.7 | 10 | 2.3 | .3 | |
| 3 | 9 | 42 | 4 | .3 | Navy 5 yr |
| 4 | 3.5 | 13 | 2 | .5 | |
| * 5 | 13 | 6 | 10 | (1.5) | (ATC Instructor) |
| Mean (enlisted) | 6.6 | 18 | 4 | .4 | (omitting #5) |

* Interviewee #5 was given a preliminary interview during development of the interview format. Some questions answered by the other interviewees were added after his interview.

3a. Who should operate it? Only one interviewee felt that the USCG should operate the VTS. Three felt that it should be a Civil Service operation (like the FAA ATC). One interviewee suggested that it could be operated by retired pilots, masters and tug-boaters.

4. How well does this VTS meet the needs of the area? No one rated the service as excellent. Three rated it as good, one as fair, one as poor, and one as good for ferries but poor for the rest of traffic.

5. How well do masters and pilots cooperate? Tug masters received three excellent and two good ratings. Masters and pilots of cargo vessels and ferry captains received two excellent, two good, and one fair rating. U.S. Navy captains received three good and two fair ratings. Two interviewees remarked of the Navy: "They try," and noted that the others have no choice. Another noted that the Navy is improving. One interviewee said that some ship masters don't want to cooperate and that sometimes ferry captains turn the radio down.

6. <u>Is the VTS properly appreciated</u>? The interviewees split evenly on this question (half yes, half no) regarding masters, pilots and the general boating public, but were 4 to 1 in agreement that the USCG does not appreciate what the VTS does. The consensus was that masters and pilots like the advisories but object to being told what to do (to being policed), although they tolerate it. One comment was that what they don't like makes sense. It was felt that the general public doesn't fully understand the purpose of VTS's--that better public relations are needed. The feeling was prevalent that, at higher levels, the USCG neither understands the purpose nor appreciates the service of VTS's.

7. <u>Is VTS a good career assignment</u>? Four enlisted interviewees answered "No." One of these added that it is a good final assignment---for "settling in." The officer felt that it is a good assignment for enlisted men, "...but they don't think so." The main complaint was that, at a VTS, you're not doing what you chose to do; you're at a disadvantage on your next assignment, and, thus, your career is jeopardized. One bitter comment was that a VTS is "...a good place to send people if you want them out of the service."

8. Would you choose another VTS tour? Two enlisted interviewees were neutral (couldn't answer, wouldn't mind as a civilian) and three would definitely not want another VTS tour, at Seattle or elsewhere (except San Francisco).

9. Were you adequately trained for all VTS tasks? Five interviewees answered affirmatively; one didn't know. One complained of pressure and harassment (yelled at) during training but felt that the situation has since improved.

10. What part of the job was hardest to learn? One interviewee claimed he had no difficulties. Three people cited communications (one added: "..remembering what you've said--what vessels have said.") One cited local procedures and another, learning geographic locations.

11. How long did it take you to qualify? Responses ranged from 5 to 9 weeks, with a mean of 7.6. (The officer was not asked this question).

12. Have you any ideas for improving training? Two interviewees suggested less pressure on beginners, while one proposed being stricter with regard to procedures. Other suggestions were: Assign trainee to work with the same person for two weeks--then with someone else. Try to teach how the service is perceived by pilots and masters. Simulate operations in a training laboratory.

13. Have you any ideas for selecting personnel for VTS duty? Three interviewees indicated that experience in radio communications should be required. Two specified a hearing test (one commented that he had gone twelve years without having a test of his hearing). One interviewee each suggested experience in navigation and general sea duty. Other comments were that VTS shouldn't be manned by USCG personnel, that career personnel should not be selected, that radarman and quartermaster ratings are appropriate, and that VTS assignments should start with a probationary period.

14. How do you like the present watch schedule? No interviewee expressed dislike of the present schedule. One considered it a reward for the 120-hour weeks of sea duty. One complained of the 40-hour requirement, noting that 72 hours is inadequate for a weekend--96 would be better. One preferred 12 hours for 4 days rather than 8 hours for 5 days.

15. How would you like team scheduling? Two interviewees would like team scheduling; four would not. Two warned of the formation of cliques. One noted that inter-team competition develops and that sections become isolated from command. One interviewee summed up team experience thus: "At first, the watch goes better if you're with the same people, but later you get tired of each other."

16. Do you have duties that take up your off-duty time? Four interviewees felt that there was some incursion of duties on off-duty time. Three mentioned check rides, although another interviewee contended that check rides could be taken on "day worker" days. One interviewee felt that only trainees need check rides--that what they learn about users' reactions can be shared with the other personnel. Other activities mentioned as being required in off-duty time were inspections and updating qualifications.

17. Rank the duty positions for difficulty. Everyone ranked the Primary Communicator position as most difficult, the External Communicator position as least difficult, and Plotter and Radar Operator positions as intermediate and about the same in difficulty. Specific factors mentioned included the mental strain as Primary Communicator, being on your feet and walking a

lot as Plotter, and boredom plus high ambient noise as Radar Operator.

18. Would it help to break the VTS area into sectors? Three interviees felt that sectorization would be helpful. Two specified four sectors: southern end, Elliott Bay, northern end, and Strait of Juan de Fuca, with each Primary Communicator on a radar terminal. Two interviewees felt that sectorization is not necessary. One said the traffic load doesn't warrant it; the other said that if a person is on the ball, he can handle it--"you earn your pay check."

19. Would you add radar sites? All interviewees agreed on the desirability of more radar sites. Two specifically noted that the present Seattle radar is in a poor location. Other specific suggestions included: Get the radar information directly to the Primary Communicator. Use a larger scope in a smaller console - like the 25 Alpha. One interviewee noted that nobody asks the watchstanders where the radar should be.

20. Might other aids improve the VTS? Five interviewees felt that computers might be useful. Although expressing lack of knowledge about computers, they suggested such uses as replacing the plotting board and assisting in televising the radar data.

Three could see no use for television. One interviewee felt that direct television surveillance would be useful on waterways. Another suggested televising the radar data. One interviewee called for better communications equipment.

21. Rate the radar for importance, usage, accuracy and coverage. Using a 4-point rating scale---High, Medium, Low, Very Low---the interviewees rated the radar as follows:

| | H | M | L | VL |
|---|---|---|---|---|
| Importance | 3 | 1 | 1 | 0 |
| Usage | 1 | 1 | 1 | 2 |
| Accuracy | 2 | 1 | 2 | 0 |
| Coverage | 2 | 0 | 2 | 1 |

Thus there was agreement that the radar is important, but a wider range of opinion on the other attributes. Comments included that the radar's importance varies with conditions, that it is used most when traffic is highly concentrated, that it would be more important if the operation were sectorized, and that accuracy for identification is poor.

22. Rate the plotting board for importance, usage and accuracy. Using a 4-point rating scale---High, Medium Low and Very Low---the interviewees rated the plotting board as follows:

| | H | M | L | VL |
|---|---|---|---|---|
| Importance | 5 | 0 | 0 | 0 |
| Usage | 5 | 0 | 0 | 0 |
| Accuracy | 1 | 2 | 2 | 1 |

Everyone agreed that the plotting board is important and gets high usage. Most rated the board as moderate to low in accuracy. One interviewee rated it high in accuracy for general position but very low for exact position and identification. It was noted that better radar would reduce the importance of the plotting board.

23. Would you like a different arrangement of equipment? Five interviewees had one or more ideas for rearrangement. Two involved moving the radar closer to the Primary Communicator, while one would put Radar Operator in the corner farthest from other activities. One interviewee suggested raising the Primary Communicator position higher above the board and moving his communications console closer and in front of him. Two suggested consolidation of External Communicator equipment at one position.

24. What is the average number of vessels in the system? One interviewee estimated 23, two 30, one 35, and two 40, for a mean of 33. Three noted that it varies considerably.

25. What is the maximum number of vessels that one watchstander can handle comfortably? Responses to this question distributed as follows:

| | Maximum Number Handled Comfortably | | | |
|---|---|---|---|---|
| | 20-29 | 30-39 | 40-49 | 50+ |
| Primary Communicator | 0 | 1 | 4 | 1 |
| Plotter | 0 | 0 | 2 | 4 |
| Radar Operator | 3 | 1 | 0 | 2 |

These judgments average 45 for the Primary Communicator, 53 for the Plotter, and 31 for the Radar Operator (within the area of radar coverage). It was noted that when the traffic count reaches 50-55, the External Communicator would assist the Plotter. On the other hand, in gill net season, when fishing advisories must be issued, the External Communicator feels overloaded with 40 vessels.

26. What situations increase the difficulty of operations for watchstanders? Answers to this question distributed as follows:

| Cause | Number Citing |
| --- | --- |
| General Public (pleasure sailing, racing) | 5 |
| Fishing | 4 |
| Weather | 3 |
| Incidents (accidents, groundings) | 3 |
| Other | 4 |

Among "other" causes, interviewees cited equipment failures on vessels, pilots failing to yield right-of-way, and lane crossings (especially between plot updates).

27. Do some VTS tasks interfere with the primary duties of watchstanders? The general response to this question was negative. Having visitors in the center was cited as distracting as well as taking a man off the job. Manipulating Simplex Time Cards was mentioned by two interviewees as interfering with communications, but necessary.

28. Regarding the issuing of cautions or directions, is it clear when you should exercise this authority and are you uncomfortable in directing experienced mariners? Three interviewees felt that policy on issuing cautions and directions was clear to them, but one said, "...you can get in trouble following it." Two felt that policy is vague, at least in some areas (such as wake reduction). Three interviewees reported no discomfort in issuing cautions and directions to experienced mariners. Two interviewees said they did feel uncomfortable; these were the two interviewees who had had the least sea duty (2 years).

29. What VTS function most badly needs improvement? Responses to this item distributed as follows:

| | |
|---|---|
| Radar | 3 |
| Communications procedure | 2 |
| Communications equipment | 1 |
| Accuracy | 3 |

Additional comments on radar noted the difficulty in concentrating for 2 hours and the need for upgraded equipment. Regarding communications procedures, one interviewee felt that too much information is passed--that information on traffic in the opposite lane and on the kind of wake is unnecessary. He

said he doesn't like to be a cop. Another interviewee felt that stricter training is required to achieve more accurate advisories.

30. <u>Can you cite instances from your own experience in which the VTS was a significant aid in resolving an incident?</u> One interviewee cited two incidents in which the VTS was able to direct other vessels to aid at an accident scene before the arrival of the SAR vessel. Another noted an occasion in which three vessels were overheard getting crossing signals mixed; by advising them, the VTS was able to avert an incident. Generalized examples included helping ferries meet schedules by giving advance information on log tows, relaying information (such as an injured man on a tug), and generally aiding in communications.

31. <u>Can you cite instances from your own experience in which the VTS caused an incident or made one worse?</u> Specific incidents included telling a ferry "no traffic" when a tanker (showing zero SOA on the board) was getting under way; directing a ferry into the path of a freighter because of mixed radar identification, and confusing a vessel by giving it the wrong direction of movement of ferries. A recent incident, mentioned several times, involved a tug going aground while the Radar Operator was getting a cup of coffee. Although it was claimed

that no VTS action could have prevented this incident, it provided negative publicity for the VTS. Generalized examples included relaxed shipboard vigilance because of reliance on the VTS, pilot leaving the wing to respond to the VTS (from fear of penalties), and unnecessary delays of vessels. One interviewee remarked that there is some such incident every couple of months, usually involving a ferry and a tanker.

32. Have you anything to add? One interviewee reiterated that the main problem is observing the radar, and another noted that the combined noise of the air conditioner and the radar equipment was high. Other added comments related to morale and included the following complaints: VTS shouldn't do police work; there should be more liberty (no Day Worker); there is loss of respect for senior grades (treated like peons); there is no chain of command; Chiefs are not using what was learned in training and have no incentive to progress, and a person can exercise too much pressure.

APPENDIX C.

STRESS LEVELS AT PSVTS

## Introduction

In staffing a Vessel Traffic Service care must be taken not to overly stress any individual watchstander. Excessive stress leads to poor morale, degenerative health, and accidents.[1] Except for comments and observations, no indications of stress present at Vessel Traffic Centers (VTS's) have been recorded. However, the Federal Aviation Administration[2] has successfully established the presence of stress in air traffic controllers, a position similar to watchstanders, using a paper-and-pencil questionnaire.

A modified version of the FAA questionnaire was administered to nine watchstanders at the Houston-Galveston VTS. The results of this survey established the presence of measurable stress at a VTS. A detailed description and results are presented in Reference 3. This same stress questionnaire was administered to 14 watchstanders at the Puget Sound VTS.

Method

Subjects: Fourteen watchstanders at the Puget Sound VTS served as subjects during breaks in their 8-hour workshifts. These watchstanders had served in the U.S. Coast Guard for an average of 7.4 years and in the Puget Sound VTS for an average of 20.2 mos.

Apparatus: The questionnaire (see Table C-2) consisted of 30 items assessing the degree of stress in terms of susceptible somatic and mood states on a continuous scale from "None" through "Moderate" to "Severe". This scale is in contrast to the items used in the FAA survey which assessed only the presence or absence of such symptoms.

Procedure: Upon finding a watchstander on a break, the experimenter introduced himself and explained that since stress had been reported at the Puget Sound VTS, a questionnaire which had been successful at measuring levels of stress at the Houston-Galveston VTS was being used to assess stress levels among watchstanders at Puget Sound. If the watchstander agreed to participate, he was given written instructions (see Table C-1). Any questions were answered, and the watchstander began filling out the questionnaire. Subjects scored each item by indicating the distance along the scale from None through Moderate to Severe corresponding to their degree of response to each item. The experimenter observed the watchstander's method of answering to

TABLE C-1. INSTRUCTIONS FOR STRESS QUESTIONNAIRE

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, MA 02142

This survey is designed to assess the physical and psychological effects you experience in connection with your work as a U.S. Coast Guard Vessel Traffic Services watchstander. Under no circumstances will your answers become a part of your personnel file or in any way affect your status in vessel traffic services work. You will be assigned an identification number so that all responses from each individual can be kept together. These data will be stored at the Transportation Systems Center until summarized. At that point there will be no further need to identify an individual's data and all forms will be destroyed.

Your task is to rate the degree of physical or psychological effects your are experiencing at the time you fill-out the rating form. You are to complete the rating form four times each working day: Just before beginning a shift, during a break or lull about half way through a shift, at the end of the shift, and at home at least three hours after a shift. You are to do this for one week.

Your specific task on each form is to rate the degree of physical or psychological effects you are presently experiencing for each item from none through severe by marking an X anywhere along the line as illustrated in the examples below. Suppose at the time you are completing the form you do not have a headache, then mark the item as shown:

1. Headache: |X________________________________|
None Moderate Severe

Suppose you do have a headache at the time you are completing the form, then depending upon its degree you might mark the item as shown:

1. Headache: |______________________X__________|
None Moderate Severe

Your cooperation is greatly appreciated. Thank you.

TABLE C-2. STRESS QUESTIONNAIRE

Complete only these first two lines.

I.D.: ______________ DATE: __________ SHIFT: __________

| TIME OF DAY | PRE | DURING | POST | HOME |
|---|---|---|---|---|
| TRAFFIC LOAD: | ____ | ____ | ____ | ____ |
| WEATHER: | ____ | ____ | ____ | ____ |

Each line below respresents a scale of symptoms you might experience ranging from none to severe. For each item below please mark an (X) anywhere along the line corresponding to the degree of symptom you are now experiencing. (you may go beyond the ends of the line if you wish.)

| | | | | |
|---|---|---|---|---|
| 1. | Headache: | None | Moderate | Severe |
| 2. | Constipation: | None | Moderate | Severe |
| 3. | Sweating: | None | Moderate | Severe |
| 4. | Twitching muscles: | None | Moderate | Severe |
| 5. | Dizziness: | None | Moderate | Severe |
| 6. | Poor appetite: | None | Moderate | Severe |
| 7. | Chest pains: | None | Moderate | Severe |
| 8. | Loose bowels: | None | Moderate | Severe |
| 9. | Loss of temper: | None | Moderate | Severe |
| 10. | Difficulty in breathing: | None | Moderate | Severe |
| 11. | Aching or burning eyes: | None | Moderate | Severe |

TABLE C-2. STRESS QUESTIONNAIRE (CONT.)

| | | | | |
|---|---|---|---|---|
| 12. | Indigestion or heartburn: | None | Moderate | Severe |
| 13. | Difficulty in staying awake. | None | Moderate | Severe |
| 14. | Stiffness or body tenseness: | None | Moderate | Severe |
| 15. | Bothered by distracting noise; | None | Moderate | Severe |
| 16. | Nausea or sick to your stomach: | None | Moderate | Severe |
| 17. | Asthma: | None | Moderate | Severe |
| 18. | Insomnia: | None | Moderate | Severe |
| 19. | Backache: | None | Moderate | Severe |

Each line below represents a scale of moods you might feel ranging from none to severe. For each item below please mark an (X) anywhere along the line corresponding to the degree of mood you feel at the present moment. (You may go beyond the ends of the line if you wish.)

| | | | | |
|---|---|---|---|---|
| 1. | Worry: | None | Moderate | Severe |
| 2. | Uncomfortable: | None | Moderate | Severe |
| 3. | Tense: | None | Moderate | Severe |
| 4. | On edge: | None | Moderate | Severe |
| 5. | Irritable: | None | Moderate | Severe |
| 6. | Fidgety: | None | Moderate | Severe |
| 7. | Depressed: | None | Moderate | Severe |

TABLE C-2. STRESS QUESTIONNAIRE (CONT.)

8. Upset: ______________________
None Moderate Severe

9. Anxious: ______________________
None Moderate Severe

10. Tired: ______________________
None Moderate Severe

11. Drowsy ______________________
None Moderate Severe

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PUGET SOUND VESSEL TRAFFIC SERVICE WATCHSTANDER ANALYSIS.(U)
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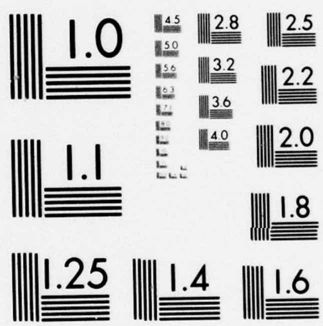


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

assure that it complied with the instructions. The questionnaire required about 2 minutes to complete.

Watchstanders then received a packet of 16 questionnaires to be completed according to the following schedule. For each of four days, watchstanders were to complete one questionnaire just prior to a shift (PRE), one about halfway through (DUR), one immediately upon ending the shift (POST), and one at least three hours later at home (HOME). Four days were specified because watchstanders work one shift for four days before taking a break. The questionnaires were then returned to the experimenter through the mail.

## Results

Nine watchstanders completed and returned their packets of 16 questionnaires. The results from the Puget Sound VTC are presented in Table C-3 in terms of median[7] ratings made for the (PRE), (DUR), (POST) and (HOME) periods. For the highest rated somatic item and mood item, the medians, together with the values below which 25 percent and 75 percent of the ratings fell, have been graphed in Figures C-1 and C-2. The numbers on the vertical

---

[7]Median: The middlemost rating; half the ratings fall above the median, half below.

## TABLE C-3. MEDIAN STRESS SCORES, PSVTS

### SOMATIC INDEX

| Item | PRE | DUR | POST | HOME |
|---|---|---|---|---|
| Aching or Burning Eyes | 0.70 | 2.19 | 2.93 | 2.16 |
| Headache | 0.58 | 1.37 | 2.05 | 1.59 |
| Distracted by Noise | 0.96 | 1.50 | 1.80 | 1.35 |
| Difficulty Staying Awake | 0.60 | 0.95 | 1.63 | 1.40 |
| Backache | 0.69 | 0.96 | 1.46 | 1.18 |
| Stiffness | 0.93 | 0.95 | 1.32 | 1.05 |
| Indigestion | 0.67 | 1.03 | 0.99 | 0.85 |

### MOOD INDEX

| Item | PRE | DUR | POST | HOME |
|---|---|---|---|---|
| Tired | 0.97 | 2.00 | 3.76 | 3.47 |
| Drowsy | 0.64 | 1.30 | 2.33 | 2.03 |
| Irritable | 0.88 | 1.06 | 1.36 | 0.87 |
| Tense | 0.72 | 1.13 | 1.24 | 1.20 |
| On edge | 0.58 | 1.01 | 1.12 | 1.08 |
| Uncomfortable | 0.72 | 0.97 | 1.03 | 0.64 |
| Anxious | 0.60 | 0.76 | 1.00 | 0.58 |
| Fidgety | 0.54 | 0.82 | 0.88 | 0.54 |

Note 1. The stress scores indicate the distances (in centimeters) along the scale from None(0 to 0.85 cm) through Moderate (3.50 to 5.25 cm) to Severe (8.0 to 9.5 cm).

Note 2. Only those items for which the Post median score exceeded 0.85, None, are tabulated.

axis indicate the distance (in centimeters) along the scale from None (0 to 0.85 cm) through Moderate (3.50 to 5.25 cm) to Severe (8.0 to 9.5 cm) at which watchstanders marked each item. These items are typical in that every item exhibited a worsening trend throughout the watch, with partial recovery later at home. The spread of ratings about the medians is also typical of the spread in the other items.

Tables C-4 and C-5 present these results ordered by the magnitude of the post-shift median scores for those items in which the median rating exceeded 0.85. Seven of the 19 somatic items and eight out of the 11 mood items indicated appreciable stress. The most sensitive items were "Aching or Burning Eyes" and "Tiredness".

Ratings tended to be essentially the same for all four days of the watch period.

The results of the original FAA survey are also presented in Table C-4 in rank order. Although not perfect, the two rankings agreed fairly well (Spearman rank-order correlation = 0.81, $p<0.0005$), lending support to the validity of the survey.

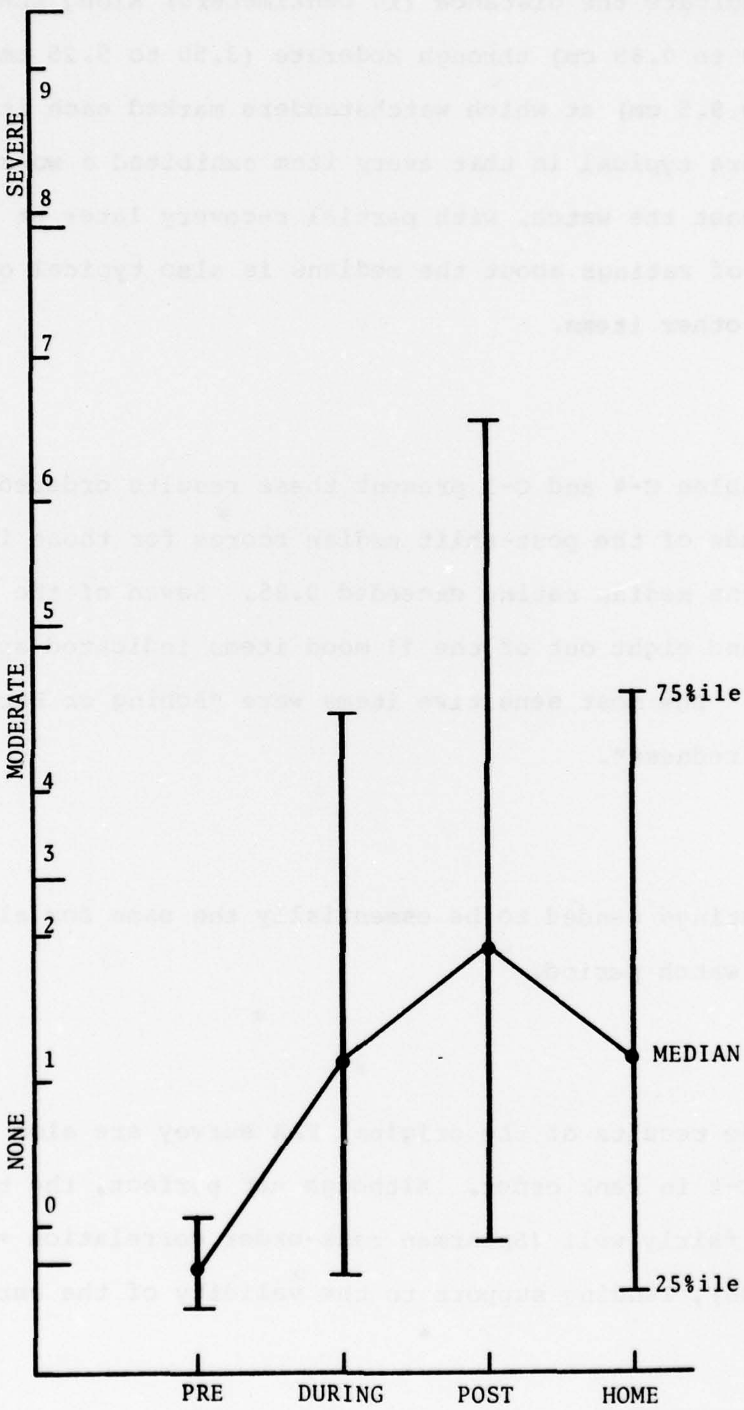


FIGURE C-1. ACHING OR BURNING EYES. PUGET SOUND VTS
NINE SUBJECTS, FOUR DAYS EACH

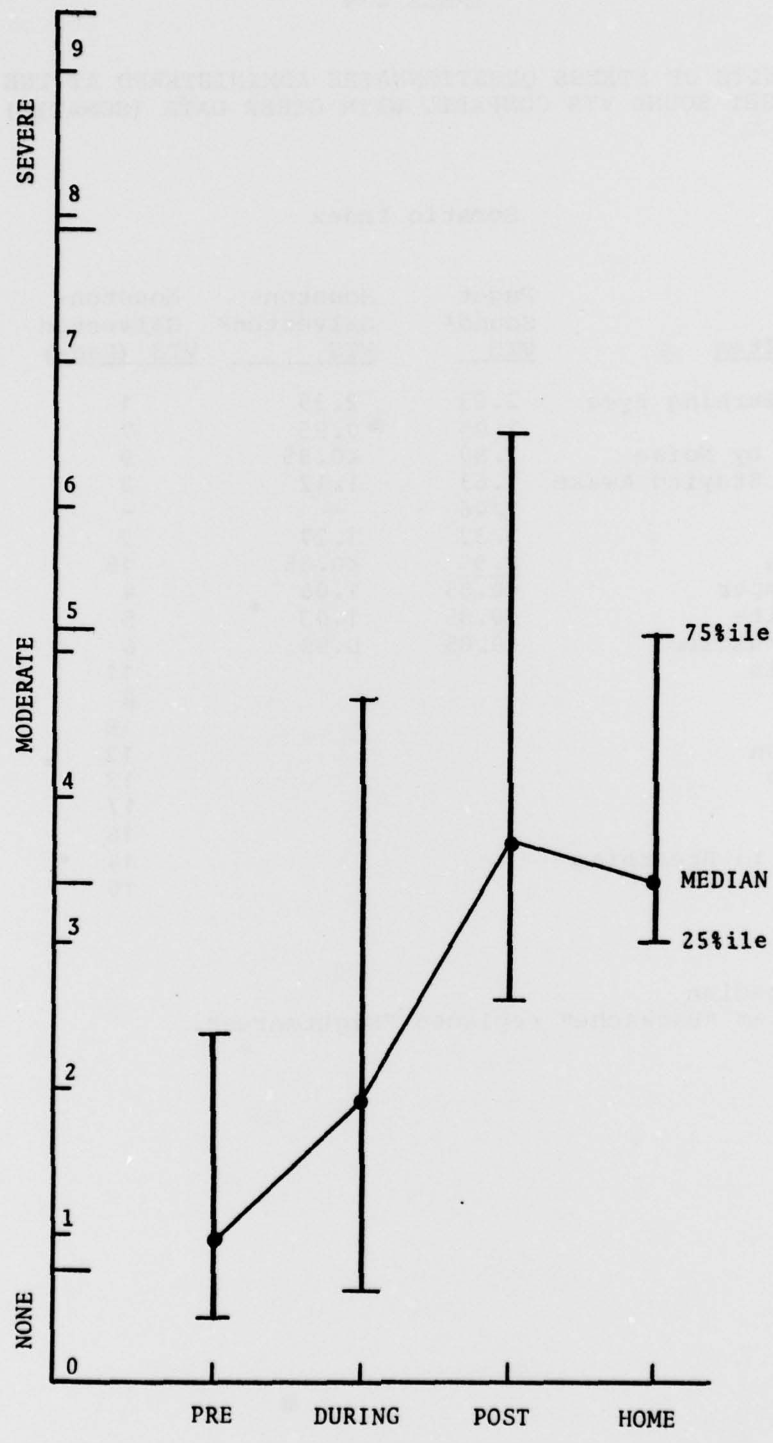


FIGURE C-2. TIRED. PUGET SOUND VTS.
NINE SUBJECTS. FOUR DAYS EACH.

TABLE C-4

RESULTS OF STRESS QUESTIONNAIRE ADMINISTERED AT THE PUGET SOUND VTS COMPARED WITH OTHER DATA (SOMATIC)

Somatic Index

| Item | Puget Sound[1] VTS | Houston-Galveston[2] VTS | Houston-Galveston VTS (Rank) | FAA (Rank) |
|---|---|---|---|---|
| Aching or Burning Eyes | 2.93 | 2.39 | 1 | 1 |
| Headache | 2.05 | 0.95 | 7 | 3 |
| Distracted by Noise | 1.80 | <0.85 | 9 | 6 |
| Difficulty Staying Awake | 1.63 | 1.12 | 3 | 5 |
| Backache | 1.46 | - | - | - |
| Stiffness | 1.32 | 1.27 | 2 | 4 |
| Indigestion | 0.99 | <0.85 | 15 | 8 |
| Loss of Temper | <0.85 | 1.06 | 4 | 7 |
| Poor Appetite | <0.85 | 1.03 | 5 | 10 |
| Twitching Muscles | <0.85 | 0.98 | 6 | 9 |
| Loose Bowels | | | 11 | 16 |
| Sweating | | | 8 | 2 |
| Nausea | | | 18 | 14 |
| Constipation | | | 12 | 11 |
| Chest Pains | | | 13 | 13 |
| Asthma | | | 17 | 17 |
| Insomnia | | | 16 | 18 |
| Difficulty in Breathing | | | 14 | 12 |
| Dizziness | | | 10 | 15 |

1. POST Median
2. The item "Backache" replaced "Nightmares".

TABLE C-5

**RESULTS OF STRESS QUESTIONNAIRE ADMINISTERED AT THE PUGET SOUND VTS COMPARED WITH OTHER DATA (MOOD)**

**Mood Index**

| Item | Puget Sound VTS | Houston-Galveston VTS | Houston-Galveston VTS (Rank) |
|---|---|---|---|
| Tired | 3.76 | 3.09 | 1 |
| Drowsy | 2.33 | 1.12 | 7 |
| Irritable | 1.36 | 1.46 | 5 |
| Tense | 1.24 | 1.64 | 2 |
| On Edge | 1.12 | 1.55 | 4 |
| Uncomfortable | 1.02 | 0.90 | 8 |
| Anxious | 1.00 | 1.35 | 6 |
| Fidgety | 0.88 | 1.57 | 3 |
| Depressed | | | 11 |
| Upset | | | 10 |
| Worry | | | 9 |

The results of the survey conducted at the Houston-Galveston VTS are also presented in Tables C-4 and C-5 for both somatic and mood indices. A comparison of the somatic questionnaire results from these two centers revealed a) a different rank order or pattern of items for each center, and b) greater levels of reported stress for those Puget Sound items in which the median rating exceeded 0.85.

"Aching or Burning Eyes" ranked highest for both centers; however, for Puget Sound, "Headache" ranked next. "Disturbed by Noise" ranks third although this item did not exceed a rating of None at Houston. "Difficulty in staying awake" was fourth. "Backache" replaced "Nightmares" for the Puget Sound survey, and this item ranked fifth, well above a rating of None. "Stiffness" ranked sixth at Puget Sound. "Indigestion", ranking seventh, was the final item to be rated above None at Puget Sound; it was not that highly rated at Houston. "Loss of Temper", "Poor Appetite", and "Twitching Muscles", all items rated above None at Houston, were not that highly rated at Puget Sound. In general, however, the two rankings did agree fairly well (Spearman rank-order correlation = 0.65, $p<0.001$).

For those items rated above None, the magnitude or level of stress reported at Puget Sound exceeded that from the Houston-Galveston VTS Center. For instance, on the leading item "Aching or Burning Eyes", the median response for watchstanders at Puget Sound was 2.93 compared to 2.39 for those at the Houston-Galveston center.

Comparison of the results on the Mood index (Table C-5) again revealed a) a different order or pattern of items between each center and, b) greater levels of reported stress on some items, less on others. "Tired" ranked highest at both centers. "Depressed", "Upset", and "Worry" were not rated above None at either center. The items in between were distributed somewhat differently between two centers; however, the two rankings agreed fairly well (Spearman rank-order correlation = 0.67, $p<.005$).

Higher levels of stress were reported at the Puget Sound VTS for the items: "Tired", "Drowsy", and "Uncomfortable". Houston-Glaveston VTS watchstanders reported higher levels on the other five items: "Irritable", "Tense", "On edge", "Anxious", and "Fidgety".

## Discussion

This survey of stress responses among watchstanders at the Puget Sound VTC demonstrated elevated levels of stress on both somatic and mood items. In general, there was a worsening trend throughout the shift for all items. In particular, "Aching or Burning Eyes" and "Tiredness" were the most sensitive of the somatic and mood items.

The highest ranking items were the same for the Puget Sound and Houston-Galveston centers and were probably a result of the nature of the watchstander task. The differences between the centers may be explainable on the basis of the differences in equipment, layout, and procedures at the two centers.

At the Puget Sound VTC, watchstanders worked together standing at a large map displaying all of the traffic, while at the Houston-Galveston VTC, each watchstander sat before a computer-driven cathode-ray tube displaying only vessels within his sector. There was some radar coverage at each center. "Headache" and "Distracted by Noise" ranked high at Puget Sound and low at Houston. These higher rankings at Puget Sound could be due to glare from the map surface, considerable background noise due to air blowers and necessary talking back and forth,

long radar watches in very low illumination, and difficulty in reading radar displays. Vessels are not split among several watchstanders at Puget Sound, whereas they are at Houston. Some of the "Headache" response may thus be due to the pressures of feeling responsible for all vessels at Puget Sound rather than for a defined set of vessels. The fact that the Puget Sound service is mandatory may contribute to these pressures.

Watchstanders at both centers reported about the same level of "Difficulty in Staying Awake". However, "Backache" and "Stiffness" were reported at Puget Sound, where watchstanders must stand next to, lean over, and reach across a large, waist-high map table. It is interesting that "Indigestion" is present at Puget Sound even though watchstanders eat comfortably at the External Communications position and prepare their meals in an adjacent room.

The ratings on the Mood index reveal watchstanders at Puget Sound to feel more "Tired", "Drowsy", and "Uncomfortable" possibly from having to stand, lean, and reach often. On the other hand, they reported being less "Irritable", "Tense", "On edge", "Anxious" and "Fidgety" than did watchstanders at Houston. Perhaps, this difference exists because watchstanders at Puget Sound are not restricted to sitting in one place, unable to interact with other watchstanders, as are those at Houston.

## Conclusions

1 - There is a worsening stress pattern on both the somatic and mood indices during the shift for all items. The pattern of somatic stress indicators is similar to that found by the FAA

2 - "Aching or burning eyes" and "Tiredness" are the most sensitive of the Somatic and Mood items

3 - Comparisons between the Puget Sound and Houston-Galveston centers reveal differences which may be explainable on the basis of differences in equipment, layout, and procedures.

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APPENDIX D.

# VISIT TO PUGET SOUND PILOTS ASSOCIATION

## D.1 Introduction

During the week of data collection at the PSVTS, the opportunity arose for the TSC research team to visit the offices of the Puget Sound Pilots Association and converse with members of the Association's Board of Directors. Four TSC representatives talked to six of the pilots, including the Association President, Captain Soriano. The discussion was informal. Each pilot expressed his feelings about the PSVTS and answered questions raised by the TSC visitors.

The discussion was generally limited to complaints about VTS policies and services and suggestions for improving the service. Highlights of these remarks are summarized below. They are presented essentially as given, without any attempt to judge or evaluate them.

## D.2 Complaints

### D.2.1 Complaints about Policy

The pilots present expressed their sincere desire for traffic safety and their agreement that traffic control and information are important. They feel that the lane separation (TSS) and bridge-to-bridge communications are the greatest aids to safety in Puget Sound. They feel strongly, however, that the VTS should not be operated by the U.S. Coast Guard. They explained that, as a military rather than a civilian operation, the system provides no court of appeal. There is no independent judge or arbitrator; rather, the USCG acts as sole judge, jury and prosecutor. "The military arm is to protect us, not to prosecute us."

Citations are a sore point. Although the pilots readily admit the need for enforcement of safety rules, they object to the nature and language of written citations, feeling that the public reprimand and the threats of fines and suspension noted as possible penalties are not the best way to achieve compliance. As an alternative, they commended the Canadian practice of calling in the offending pilot or master for a private discussion of the problem and possible solutions. They also object to the use of voice tapes as evidence for citations, considering it a breach of faith in light of earlier promises regarding VTS.

Another consequence of operation of the PSVTS by the USCG that is particularly objectionable to the pilots is the staffing of the operation by personnel far less skilled in the problems of handling vessels in Puget Sound than the pilots and masters on the vessels. Coast Guard watchstanders are generally young, have limited experience with large vessels--and that mostly in open waters, are not local people, and are at the PSVTS for only two-to-three years before being reassigned. The pilots stated that watchstanders appear to replace judgment with rote responses.

### D.2.2 Complaints about Services

The pilots present complained that the PSVTS both requests and imparts too much information. They feel that VTS personnel ask for unnecessary information, have irrelevant conversations, and don't address their real problems. In addition, the pilots indicate that they can't assimilate, remember and use all of the information given in advisories. They also claim that sometimes the information is wrong, particularly in the waterways.

A second major complaint is that the radio channels are overloaded--that they can incur delays of 5-to-10 minutes in getting into a channel.

There was an implication of inherent proprietary rights in the complaint: "They tell you about gill netters and sailboats but don't get them out of the way."

## D.3 Suggested Improvements

The pilots present offered a number of specific suggestions for improvement of the services. These included:

Operate the VTS under civilian authority, employing retired or part-time active pilots and masters as watchstanders.

Increase the number of radio channels.

Limit position reporting to checking in and out of the system.

Give advisories only on cross traffic and unusual conditions, not on routine conditions.

Generally give advisories only when asked for them.

Eliminate advisories on traffic in the opposite lane.

Eliminate precautionary areas.

Give tankers priority over tow boats.

Give outbound traffic priority in Rich Passage.

Install television coverage of Rich Passage.

Cut down on talking on VTS channels.

Study the vessel traffic management systems of Japan, Holland and Germany for methods and procedures that might improve the PSVTS.

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